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PROCEEDINGS

FOURTH MEETING, SECOND HALF, 66TH SESSION

A Joint Meeting of the Royal Aeronautical Society and the British Gliding Association was held on Thursday, 26th February, 1931, at 6.30 p.m., at the Royal Society of Arts, John Street, Adelphi, W.C.2, Colonel the Master of Sempill presiding, to hear a Paper read by Captain F. Entwistle, B.Sc. (Superintendent, Aviation Division, Meteorological Office, Air Ministry), entitled

THE METEOROLOGICAL ASPECTS OF GLIDING AND SOARING FLIGHT

BY

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1 The Development of Aviation

1. The development of aviation, particularly since the War, has led to a growing demand for information on various aspects of meteorological science as applied to flying, and the investigation of the problems thus raised has helped considerably towards increasing our knowledge of the atmosphere and its mechanism. In so far as the subject of wind structure is concerned, attention has been concentrated mainly on the accumulation and interpretation of data regarding the average direction and speed of the wind currents at different levels in various parts of the world. The horizontal variations of wind and the vertical currents which disturb the regular flow of air have received, in comparison, little consideration. The latter aspect of the subject is of paramount importance in connection with the problem of soaring flight; it is also related to the more general question of the stability of aircraft. It may not be out of place here to quote the concluding paragraph of an article, written in 1922, describing the meteorological conditions associated with the Gliding Contest held at Itford Hill in that year (1).

> "This new branch of aeronautics has opened up an interesting and important field of investigation, fascinating alike to the meteorologist and the aviator, in which little has hitherto been done."

The latter part of that statement is, unfortunately, still true to-day, but it must be remembered that in this country, apart from the temporary interest aroused in gliding flight in 1922, the gliding movement is a comparatively recent development. There is little doubt that had the interest in the movement which started in 1922 been sustained during the intervening period, there would be a very different story to tell to-day in regard to those aspects of meteorology which are closely associated with soaring flight.

2 *Conditions for Gliding and Soaring Flight*

The necessary conditions for gliding and soaring flight were first definitely enunciated in 1883 by Lord Rayleigh (2), who expressed them in the following terms :—

Either (1) The course is not horizontal
or (2) The wind is not horizontal
or (3) The wind is not uniform.

The first of these conditions is that of ordinary gliding, while the second and third alternatives relate to soaring flight. The second and, from the point of view of present-day soaring, the most important alternative, refers to the case in which there is a sufficiently strong upward component to the wind stream to sustain the aerodyne without loss of height, while the third alternative represents the more theoretical case in which the energy for soaring is derived from the fluctuations which occur in a turbulent wind. To the latter case the term " dynamic soaring " has been applied by Lanchester (3).

It will be evident that in order to understand fully the conditions for soaring flight a detailed knowledge of wind structure is necessary. In the present paper it is proposed first to review briefly the present state of knowledge in regard to disturbed wind conditions; secondly, to consider some of the more important practical applications to gliding and soaring flight; and finally to suggest a possible programme of further investigation and development.

3 *Wind Structure*

The disturbances which prevent the regular flow of wind over the earth's surface may be divided into three categories :—

(*a*) Small-scale disturbances which are the direct result of turbulence and are due to surface friction.
(*b*) Intermediate disturbances due to larger obstructions in the path of the wind or to moderate convection.
(*c*) Large-scale disturbances due to masses of high ground or to strong convection.

This classification is convenient, also, from the point of view of the practical application of the various kinds of disturbance to soaring flight.

(*a*) *Small-scale Disturbances.*

(i) GUSTINESS.—It is a well-known fact that the wind near the ground is rarely steady, but that it blows in a succession of gusts and lulls, both speed and direction varying from moment to moment. This " gustiness " is well illustrated in the records from a Dines' pressure tube anemometer, which is the standard instrument in use in this country for meteorological purposes and gives a continuous record of both the speed and the direction of the wind. An examination of the series of typical records reproduced in Fig. 1 reveals that the velocity trace is not a straight line as it would be in the case of streamline motion, but that it consists of a succession of short period up-and-down oscillations. The direction trace has a similar character.

It is seen, further, that the range of gustiness increases as the average wind speed increases; the one is, in fact, directly proportional to the other. The range of gustiness also depends on the nature of the surface over which the wind is blowing. This is illustrated by the two records in Fig. 2. The upper record is from the anemometer established recently on the Bell Rock Lighthouse, which has a particularly open exposure in all directions and exhibits a remarkably small range of gustiness as compared with the second record, which is from an instrument at an inland station in closely wooded country.

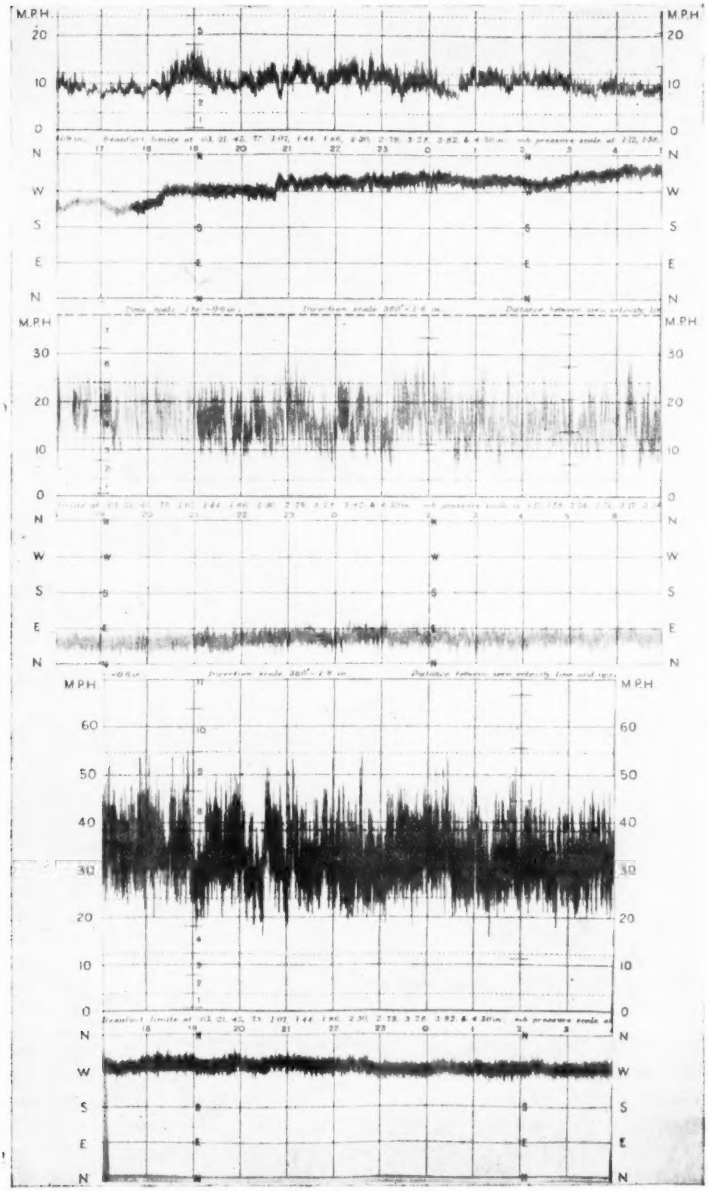


FIG. 1.

Anemograms for Croydon showing increase of gustiness with increase of mean wind speed.

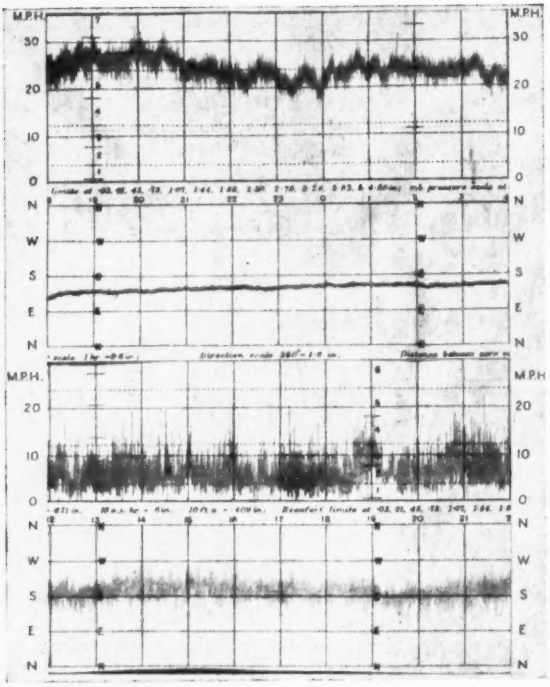


FIG. 2.

Anemograms from Bell Rock and Dyce showing effect of exposure on gustiness.

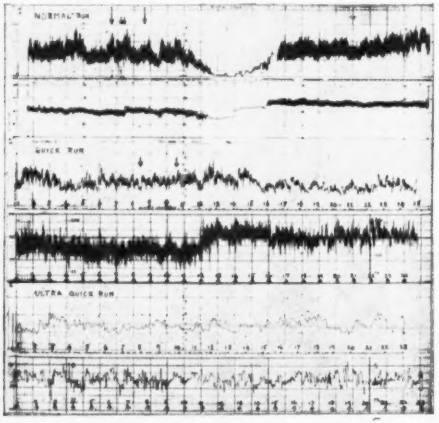


FIG. 3.

Open-scale anemograph records.

The individual character of the gusts is seen more clearly in the records reproduced in Fig. 3, which were obtained at the Royal Airship Works, Cardington. The first record was made in the normal way, but by using a quick-run clock, the second and third records were obtained on very open time scales. The second record (quick-run) comprises the portion of the first record between the two arrows which are furthest apart, while the third record (ultra-quick-run) comprises the portion of the first record between the two arrows which are close together, this portion corresponding to the interval between the two arrows in the second chart. The duration of the records are 24 hours, 2 hours, and 10 minutes respectively. The numbers at the foot of each record indicate the positions of time marks. It will be observed from the third record that the duration of a gust is of the order of a few seconds.

The way in which gusts retain their individual characters over a period of time is indicated by the sequence of records in Fig. 4. The first and second

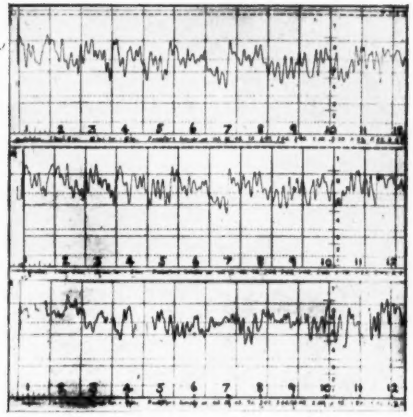


FIG. 4.
Open-scale anemograph records from three anemometers lying along the direction of the wind.

records are quick-runs from anemometers 4 feet apart, while the first and third records are from anemometers 350 feet apart, all three instruments lying along the direction of the wind. Selected individual gusts can be traced by their characteristics from one record to another, the time interval between the third and second records being, naturally, greater than that between the second and first records.

The Dines' pressure-tube anemometer registers only the *horizontal* variations in the wind. The variations in the vertical have been studied by G. I. Taylor (4), who used for the purpose a light wind vane mounted at its centre of gravity by a universal joint so that it would point in the actual direction of motion of the air at any moment. A record of the motion of the vane was obtained by means of a pen attached to a point on its arm and writing on a paper. Taylor found that the three components of the eddy movement of the air (i) in the direction of the wind, (ii) in a horizontal cross-wind direction, and (iii) vertically, were approximately equal. The equality between (i) and (ii) was established from a consideration of the average variation in the speed and direction of a uniform wind as obtained from the records of a Dines' anemometer, while the equality between

(ii) and (iii) was established from the records of the special vane referred to. More recent work carried out by Scrase (5) indicates that the vertical component of eddy motion is rather less than the horizontal components. Scrase employed the same type of bi-directional vane as that used by Taylor, but also carried out further experiments using a vertical gustiness recorder and a special bi-directional vane fitted with small anemometers to record the mean wind speed and the horizontal component of eddy velocity in the direction of the wind. The latter was

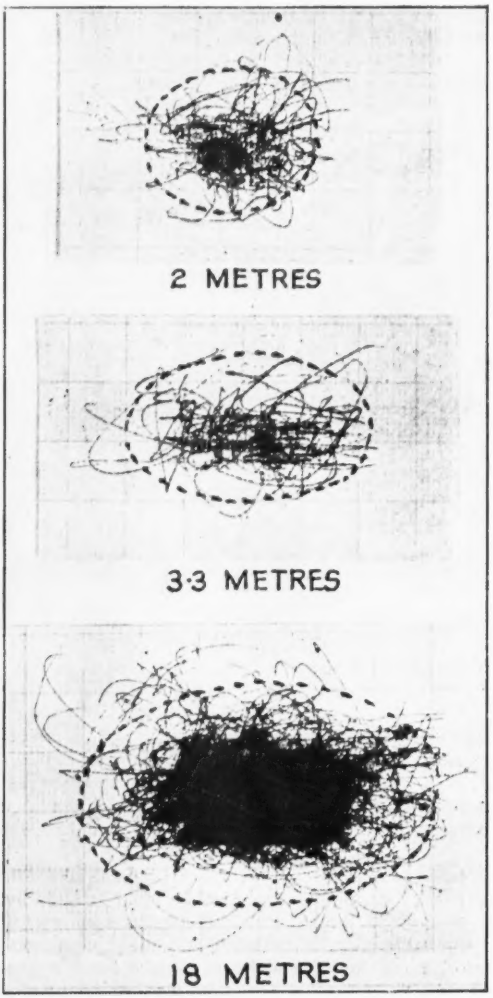


FIG. 5.

Typical records of vertical gustiness obtained with a small bi-directional vane at different heights above the ground.

used in conjunction with a kinematograph camera in order to introduce a time scale into the records. Fig. 5 shows some typical diagrams obtained by Scrase with the bi-directional vane at different heights above the ground.

The foregoing considerations lead us to picture the air near the ground as full of approximately circular but somewhat flattened eddies rapidly forming and dissipating again, and having axes of revolution in all directions. The eddies owe their origin to friction between the moving air and the surface of the ground. The eddy motion increases as the mean wind increases and varies with the nature of the surface over which the wind is blowing.

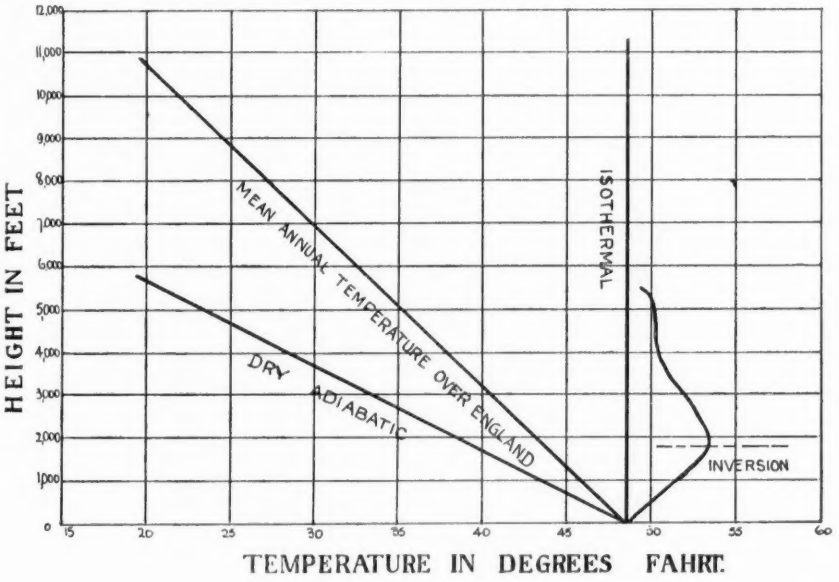


FIG. 6.

Some typical lapse rates.

(ii) EFFECT OF TEMPERATURE.—The question now arises as to what happens at some height above the surface of the ground. It follows from a consideration of the cause of formation of eddies that on the average eddy motion will tend to decrease with height, but in order to answer the question more fully, it is necessary to consider the temperature of the air and the manner in which it varies with height above the ground. On the average, temperature falls off with increasing height, the average rate of decrease being 3°F. per 1,000 feet, although the actual rate of decrease or " lapse rate " on a particular day may differ considerably from the average value, particularly in the lower layers near the ground. There are two extreme cases which it is necessary to consider from the point of view of the present discussion. The first is that in which the thermal structure of the air is said to be " adiabatic." This may be understood by considering a mass of air near the ground which becomes heated above the temperature of its surroundings and rises. As the air rises it becomes cooled by expansion owing to the fact that pressure diminishes with increasing height. If there is no gain or loss of heat from outside, the air, provided it is not saturated with water vapour, becomes cooled at the rate of $5\frac{1}{2}$°F. per 1,000 feet. This

particular rate of decrease of air temperature with height is called the "dry adiabatic lapse rate." It follows that if the general lapse rate in the lower atmospheric layers is greater than the dry adiabatic, air rising from near the ground will go on rising, for at any height it will be warmer, and therefore lighter than its environment. In such conditions the atmosphere is said to be *unstable*. The second case is that in which the temperature of the air, instead of decreasing with height, actually increases, forming an "inversion." This is a very stable condition, for any tendency on the part of the air to rise is immediately checked. These two extreme cases, together with other typical lapse rates, are shown diagrammatically in Fig. 6.

The temperature considerations just described have a very important bearing on eddy motion. The more the temperature lapse rate approaches the adiabatic state the more the eddies formed near the ground tend to spread upwards and to grow, while in an inversion they tend to keep near the surface of the ground and to be damped out. It follows that on the average these disturbed conditions extend to a greater height in the day than at night, and also to a greater height in summer than in winter.

Photograph taken from the air by Captain C. K. M. Douglas.

FIG. 7.

A typical horizontal sheet of strato-cumulus.

(iii) FORMATION OF CLOUD BY EDDY MOTION.—Eddies near the ground are made visible to the eye by a trail of smoke, for example, from a factory chimney. In the upper air they frequently give evidence of their existence in the formation of cloud. One type of cloud produced by eddy motion is the familiar strato-cumulus which, in its most typical form, covers the sky either as a continuous sheet or in broken patches, the cloud being arranged in waves or rolls which are evidence of the turbulent motion within and beneath it. An example of such a cloud sheet, viewed from above, is shown in Fig. 7. The formation of these clouds is explained by the spreading upwards of the eddies set up near the ground by a wind current blowing over a relatively warm surface. The turbulent mixing of the air in successive horizontal layers results in a temperature lapse rate approaching the adiabatic state. The moisture carried upwards by the eddies condenses, forming a sheet of cloud which extends from the level at which the dew point is reached to the top of the layer affected by the turbulence. The temperature at the top of this layer having been reduced by the eddy mixing, there is, in a well-developed strato-cumulus sheet, a pronounced inversion above

the cloud, the air at this level being undisturbed in contrast to the turbulent conditions within and beneath the cloud. Fig. 8 illustrates a ragged layer of strato-cumulus which indicates very turbulent conditions.

Another example of cloud formed by eddy motion is the ragged broken cloud which forms below rain clouds in bad weather, the moisture being carried upwards

Photograph taken from the air by Captain C. K. M. Douglas.

FIG. 8.

A turbulent layer of strato-cumulus.

in this case by the eddies from the saturated air near the ground. If the wind is strong, this cloud appears in large heavy masses. An example is shown in Fig. 9.

Photograph by Mr. G. A. Clarke.

FIG. 9.

Low ragged cloud formed by eddy motion below rain cloud.

(*b*) *Intermediate Disturbances.*

(i) TOPOGRAPHICAL.—It was stated in the preceding section that the eddy motion produced in a current of moving air depends on the nature of the surface over which the wind is blowing. Eddies are formed when the wind blows over a level surface such as a stretch of sea or open grass land, but obstacles such

as hedges, houses and trees increase the eddying considerably and also the height to which the effects are felt. In the case of a large obstacle such as a house or a hangar, much larger eddies are produced than in the case of wind blowing over, say, open grass land. Fig. 10, which is taken from a paper by J. S. Dines (6), shows the wind currents behind a building 15 feet high with a wind of 15 to 20 m.p.h. blowing over it. The drift of the wind currents was observed by smoke and by means of a tethered balloon.

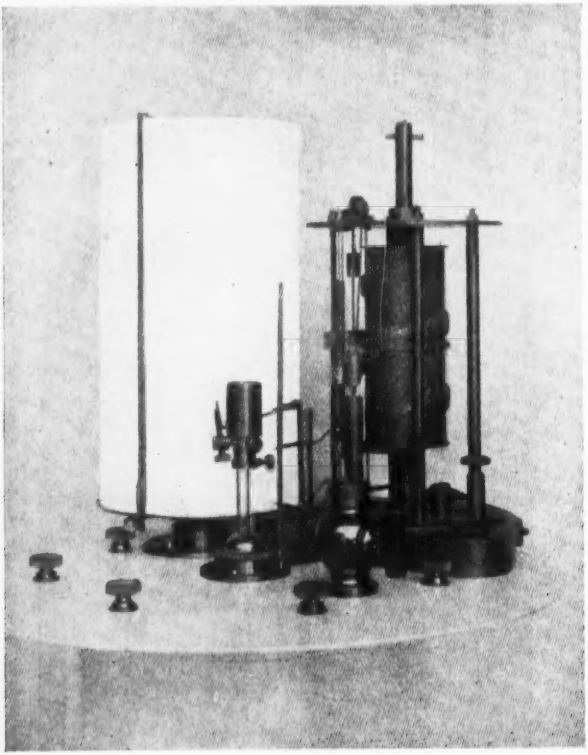


FIG. 10.

Direction recorder mounted on top plate of normal pressure tube anemometer.

In the case of wind blowing over broken ground we can therefore picture the disturbance as consisting of a number of large eddies with smaller eddies moving within them. As in the case of the smaller eddies alone, the disturbance would be transmitted upwards to a greater height on a day when the temperature lapse rate was large than it would be on a day when the atmosphere was relatively stable. In the latter case, when conditions are steady, the wind stream tends to follow the contours of the ground.

(ii) THERMAL EDDIES FORMED BY HEATING OF GROUND.—There is another way in which disturbances of appreciable size can be produced, and that is by the process of convection, or the ascent of air which has been warmed by contact

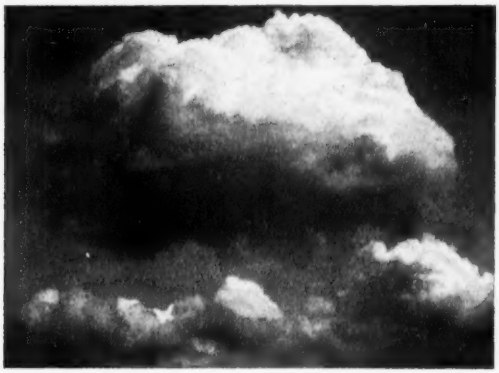
Photograph by Mr. G. A. Clarke.

FIG. 11.

Small cumulus clouds growing.

with the ground. All air pilots are familiar with disturbances of this kind. On a hot day, as the surface of the ground becomes heated, the atmosphere rapidly approaches the unstable adiabatic state and streams of air flow upwards from the ground. A small cumulus cloud forms at the top of each rising current and between the clouds are found regions of descending air or return currents which restore the balance of the circulation. A typical sky of this type, in which the cumulus clouds are growing, is shown in Fig. 11.

In the absence of definite measurements it is a little difficult to picture the exact air circulation between the ground and the level of the cumulus clouds. Near the ground there is rarely a definite upward current, the air rising in thin streams which are intermingled with streams of descending air. As a cumulus cloud grows, a powerful upward circulation develops within it and this draws in air from lower levels. The upward current thus reaches its maximum intensity immediately below and within the cloud. Fig. 12 shows a photograph of a more fully developed cumulus cloud.



Photograph by Mr. G. A. Clarke.

FIG. 12.

Well developed cumulus cloud.

On days of strong surface heating marked contrasts are observed over different kinds of ground. Bare rocky or sandy soil becomes heated much more readily than land covered with grass or vegetation, or open water, and marked up-currents may be observed over the one and down-currents over the other. Even over a tarmac road passing through cultivated land a definite up-current may be felt.

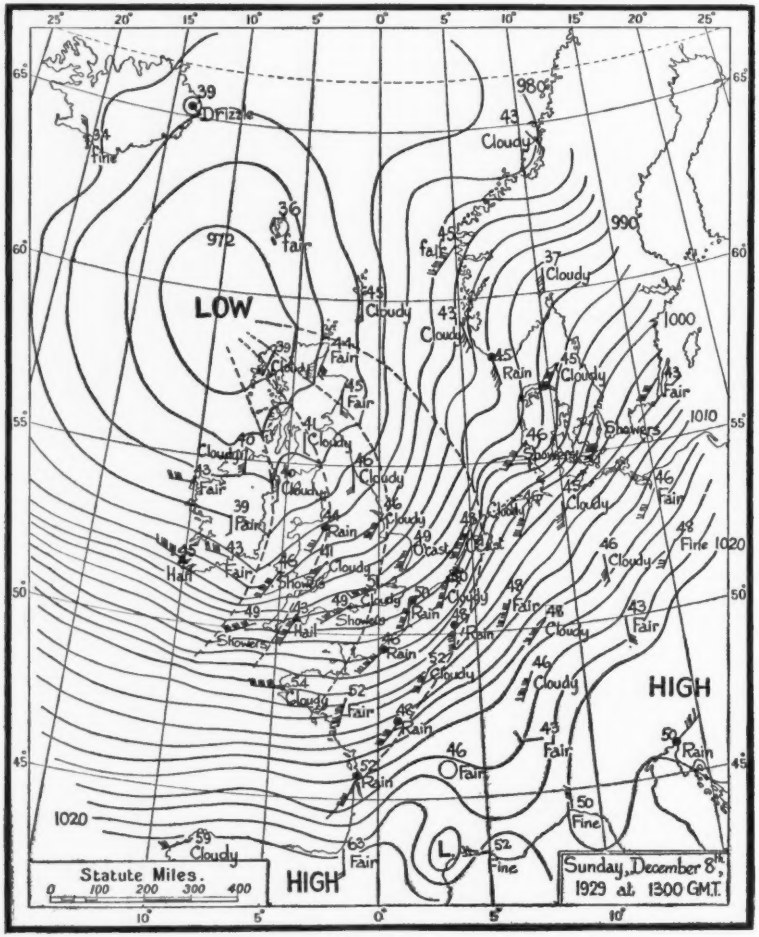


FIG. 13.

Weather chart for Sunday, December 8th, 1929, at 13.00 G.M.T.

(iii) SQUALLS PRODUCED BY FLOW OF COLD AIR OVER RELATIVELY WARM SURFACE.—As another example of the formation of relatively large disturbances by convection may be cited the case in which a cold wind current from high latitudes reaches this country after passing over a stretch of relatively warm sea. Owing to surface heating the air becomes unstable up to considerable

heights and disturbances in the nature of squalls develop in the wind current, superposed on the smaller eddies which are formed as previously described. The weather chart for 1 p.m. G.M.T. on 8th December, 1929 (Fig. 13) affords an example of a situation in which such squalls readily develop. The westerly wind current reaching this country from the Atlantic has travelled round the area of low pressure seen to the west of Scotland and is of polar origin. The air reaching the extreme south of the country, however, has followed a more southerly course and surface temperatures along the Channel and in the south-east of England are some 5° to 10°F. higher than to the west and north. Along the boundary of this warmer current the air was very unstable. The anemometer record from Croydon for the 8th-9th, which is reproduced in Fig. 14, shows very squally

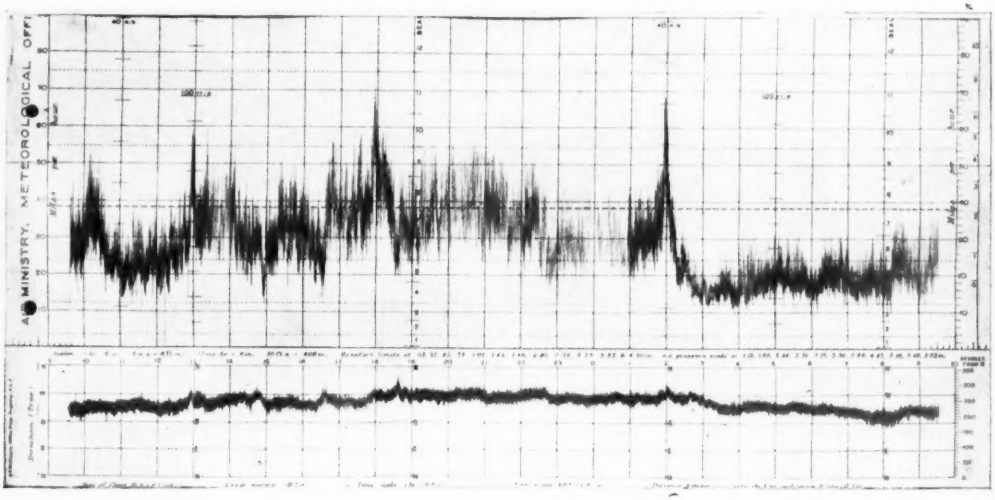


FIG. 14.

Anemogram for Croydon.
From Sunday, 8th Dec., 09h. 35m., 1929,
to Monday, 9th Dec., 09h. 32m.

conditions with abrupt short period changes in both the speed and direction of the wind. Three extreme peaks are observed in the velocity trace at about 13h. and 18h. on the 8th and 2h. on the 9th, indicating major squalls, to which reference will be made later. The general character of the record suggests a sequence of irregularly recurring squalls superposed on the smaller-scale gustiness, which was itself considerable owing to the strength of the wind and the unstable lapse rate. The portion of the record prior to 2h. on the 9th stands out in marked contrast to the remaining portion, which corresponds with the extension of the colder air over S.E. England; the arrival of this air at Croydon corresponds with the squall at 2h.

Squalls of the character indicated would usually be marked by a strong upward current in front of the squall and a more gradual descending current behind it, the horizontal dimensions of the upward current being smaller than those of the descending current.

(iv) Regularly Recurring Squalls of Relatively Short Period.—There is another type of squall, sometimes experienced in certain localities, which is of a much more regularly recurring character than those just considered. Examples are seen in the anemometer record from Bell Rock for January 18th to 19th, 1930, which is reproduced in Fig. 15. It has been suggested that such squalls are due to waves set up at or near the horizontal boundary between two air currents (7). In certain conditions wave motion in the atmosphere gives rise to visible cloud arranged in waves or parallel bands. A sky of this type is illustrated in Fig. 16.

(c) *Large-Scale Disturbances.*

(i) Topographical.—Large-scale disturbances in which upward currents of considerable horizontal dimensions occur form the most important class of disturbance from the point of view of soaring flight. As in the case of intermediate

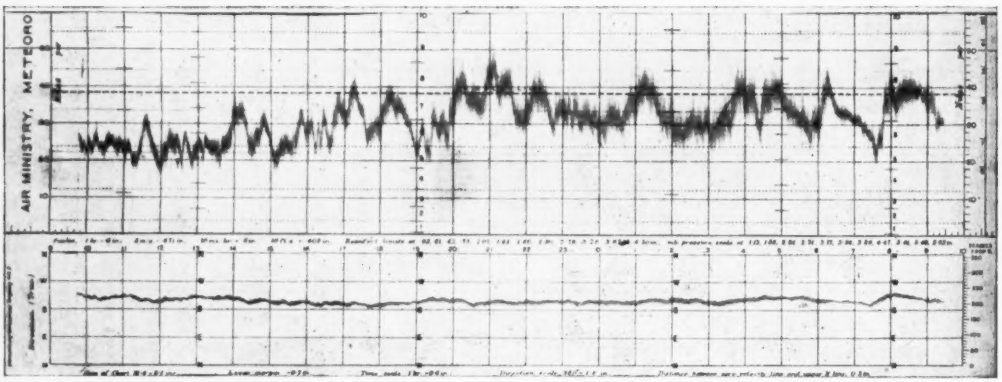


Fig. 15.

Anemograms from Bell Rock Lighthouse showing recurring squalls.

disturbances these large eddies are of two main classes, viz., those caused by topography and those due to convection. Of the first type the most persistent upward currents are found in the case of a definite wind current blowing at right angles to a ridge of hills or mountains, the upward current being strongest just above the crest of the slope on the windward side. The strength of the up-current appears to depend on the slope of the hill rather than on its actual height. A corresponding downward current occurs on the leeward side of the ridge.

The actual wind circulation over the hill depends on a number of factors. If both windward and leeward slopes are gradual and the surface is smooth, a steady non-turbulent wind will blow over the hill without forming any appreciable eddies, giving a gentle upwind on the windward side and a downwind on the leeward side. As the slopes become steeper, a return upward current may be observed close to the hill on its leeward side. This return current is more pronounced in the afternoon if the leeward side faces south, owing to the sun warming the slope. Between the downward current and the return up-current there would frequently be found a shadow area in which there was no marked wind circulation. If the surface of the hill is broken or if the wind is strong and the temperature lapse rate large, turbulent conditions may be experienced at any point in proximity to the hill. In the case of a cliff with a steep face the circu-

lation is more complicated than in the case of a ridge with sloping sides, and dangerous eddies may occur, particularly if the direction of the wind is such that the steep side of the cliff faces to leeward. These eddies may extend for a considerable distance to leeward from the cliff. Fig. 17 shows the type of

Photograph by Mr. G. A. Clarke.

FIG. 16.

Parallel bands of cloud formed by wave motion.

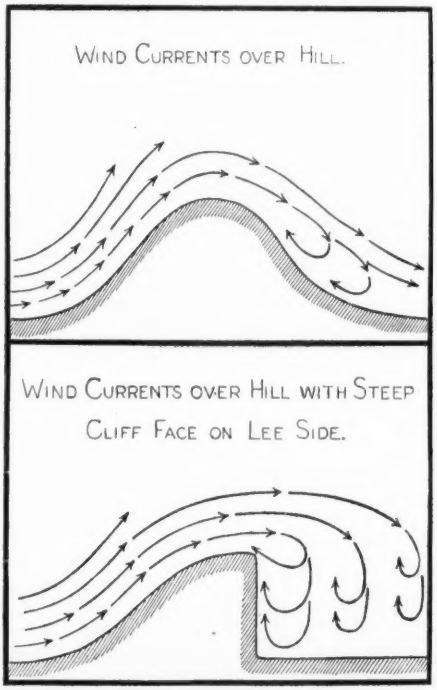


FIG. 17.

wind circulation which might be expected over a ridge with sloping sides and also with a steep cliff on the lee side.

If the wind is blowing over hilly country parallel to the direction of a main ridge which has spurs running out at right angles to the direction of the wind,

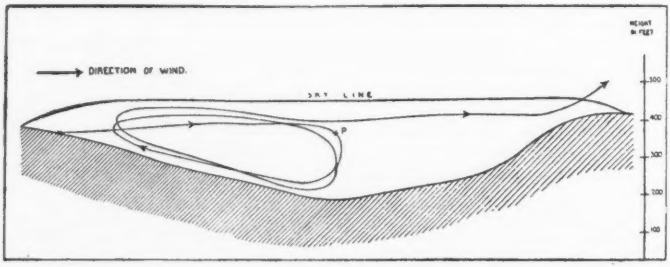


FIG. 18.

Path of a balloon with no "lift" across the valley between two spurs on the north of Itford Hill.

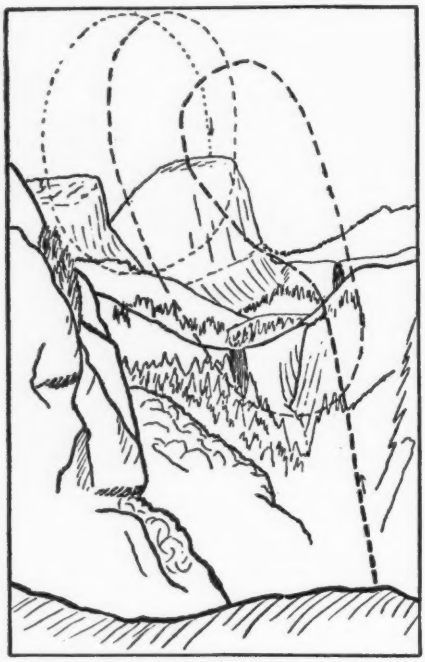


FIG. 19.

Spiral eddy observed in mountain valley in California, June 8th, 1920.

eddy effects are produced in the valleys between the spurs. Fig. 18 shows the path followed by a balloon with no "lift" across the valley between two spurs to the north of Itford Hill in such conditions (1). Another interesting example

of an eddy is shown in Fig. 19, which illustrates the circulation on a warm afternoon in a mountain valley in California when the wind was blowing up the valley. The spiral increased to about 2,000 feet in diameter at the eastern end of the valley (8).

(ii) THUNDERSTORMS.—The thermal conditions which are favourable for large ascending currents are a development from the conditions described in section (*b*). They are associated with a large temperature lapse rate and, when fully developed, produce thunderstorms. The necessary conditions may be brought about by strong surface heating of the ground on clear days, with light winds

Photograph by Mr. G. A. Clarke.

FIG. 20.

Large cumulus cloud (thunder cloud).

in summer, or by the setting in of a relatively cold upper current over a warm surface current. The strong vertical circulation which results leads to the formation of very large cumulus clouds, the rounded heads of which are seen pushing upwards and outwards. When fully developed the top spreads out into a flat-topped anvil-shaped projection. Photographs of a thunder cloud in the two stages are shown in Figs. 20 and 21. The strongest upward current occurs in front of the cloud, while within the cloud very turbulent conditions are experienced. The mode of formation of thunder clouds and the development of thunderstorms were described in detail by Dr. G. C. Simpson in a lecture before this Society in November, 1924 (9).

(iii) LINE-SQUALLS.—Strong upward currents, extending along a line many miles long, may occur in connection with a line squall. This phenomenon is associated with the " cold fronts " of moving depressions of temperate latitudes, along which the cold current in the rear of the depression is undercutting the warmer air of the " warm sector." The structure of line-squalls was discussed in very considerable detail by the late Mr. M. A. Giblett in a lecture before this Society in March 1927 (10) and it will only be necessary to emphasise here the salient features which are important from the point of view of the present discussion. Fig. 22 is a reproduction of Mr. Giblett's diagram showing the detailed structure of a line-squall. The strongest upward current occurs at *F* at the tip of the wedge of advancing cold air and may give rise to the characteristic long roll cloud of a line-squall. An example of such a cloud is seen in Fig. 23. If the warm air in front of the cold wedge is sufficiently

Photograph by Mr. G. A. Clarke.

FIG. 21.

Large cumulus cloud (thunder cloud) with anvil.

unstable a large towering cumulus will form in the space *ML* with the possibility of thunderstorms. The actual conditions which accompany the passage of a cold front depend on the physical properties of the air masses in juxtaposition and may vary between a weak convective circulation with, perhaps, a little rain, and strong vertical currents with thunderstorms and hail. Frequently a descending current occurs behind the front but this is usually relatively gradual and is spread over a much wider area than the more intense upward current in advance of the front. The three major squalls shown on the anemometer record for Croydon on December 8th, 1929 (Fig. 14), actually indicate the passage of three cold fronts over the country.

(iv) VERTICAL CURRENTS ASSOCIATED WITH SEA BREEZES.—Definite but less intense ascending currents may extend along a coast line on a hot day in summer, being associated with the sea breeze which, in favourable conditions, sets in during the morning and reaches its maximum strength in the early afternoon. Evidence of the ascending currents is provided by the line of cumulus cloud which forms over the land parallel to the coast line. Corresponding descending currents frequently occur in such conditions over the sea.

(d) Summary.

I have endeavoured in what precedes to present a broad view of the conditions which may occur in the atmosphere to produce, on a small or a large scale,

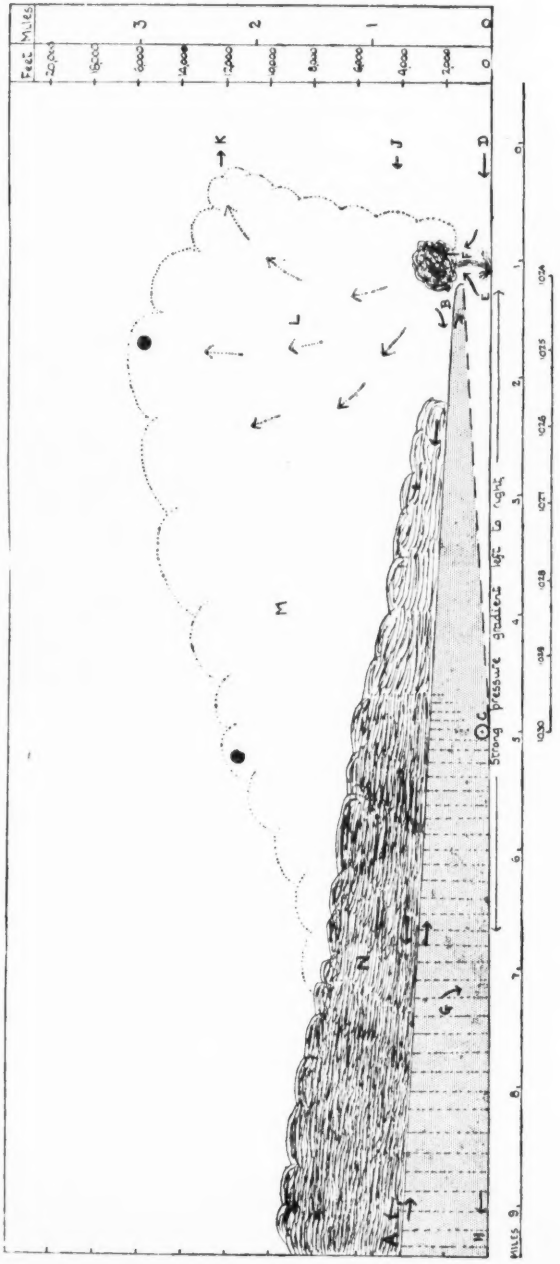


FIG. 22.
Detailed structure of line-squall.

a vertical component in the motion of the air. We can sum up by saying that conditions may vary from the stable state represented by an inversion of temperature, in which turbulence would be reduced to a minimum and the wind would tend to follow the contours of the ground, to the large and sometimes violent ascending currents associated with line-squalls and thunderstorms. Intermediate between the two extremes there may exist eddies of varying size, according to the strength of the wind and the topography of the country, conditions being more disturbed as the vertical temperature distribution approaches the adiabatic lapse rate.

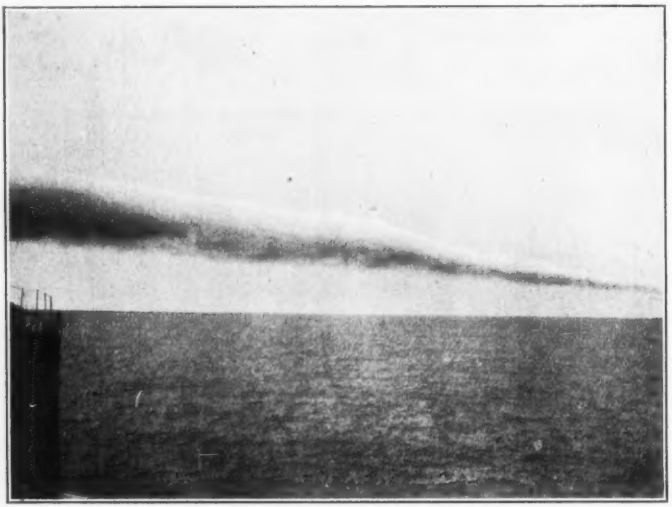


FIG. 23.

Photograph of line-squall cloud taken from ss. "Nore," Captain R. M. M. Collyer; Observer, Mr. L. J. Edwards; London to Port Said, on May 4th, 1921, at 9.30 a.m., in Latitude 32° 33′ N., Longitude 28° 28′ E.

4 Magnitude and Extent of Vertical Currents

Data regarding the magnitude and extent of vertical currents are very scarce. The normal method of obtaining information regarding wind currents is by sending up a small rubber balloon filled with hydrogen to rise at a pre-determined rate. The motion is observed by means of a theodolite and readings of the altitude and azimuth of the balloon are taken every minute. Assuming the rate of rise of the balloon (usually 500 feet per minute) it is then possible to calculate the speed and direction of the wind in consecutive layers. By attaching a long tail to the balloon and measuring its length on a graticule in the eye-piece of the theodolite, the necessity for assuming the rate of ascent of the balloon is avoided, since it is possible to calculate the height of the balloon at the end of each minute. Knowing the rate at which the balloon would rise in still air, it is then possible to determine the average up- or down-current in each 500 feet layer. The most accurate method is to use two theodolites at the end of a measured base line, but this method is not in general use owing to the additional personnel required and the length of time necessary for working up the results. Fig. 24 shows a pilot balloon with tail just after its release.

The magnitudes of vertical currents measured by the pilot balloon method are not of a very high order. This result is to be expected since only mean values through a given layer are obtained. Of 305 upward currents observed at the lower levels in a particular year 45 per cent. were less than 5 ft./sec., 42 per cent. were 5 to 10 ft./sec. and 13 per cent. were greater than 10 ft./sec. Of the descending currents observed 62 per cent. were less than 5 ft./sec. and only 4 per cent. greater than 10 ft./sec. The highest frequency of ascending currents was found below 1,500 ft., the frequency decreasing with height. The maximum frequency of descending currents was found between 1,500 and 3,500 ft.

Individual cases of special interest have been noted occasionally. An outstanding example is that of an ascending current of 27 ft./sec. observed between 1,500 and 2,000 ft. at Larkhill in unstable polar air in April 1921 (11).

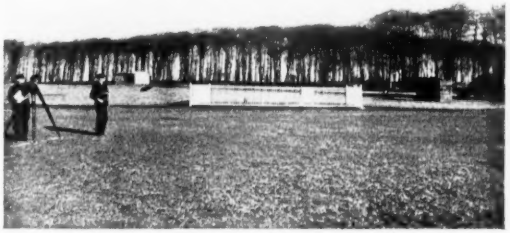


FIG. 24.
Pilot balloon with tail after release.

With regard to the more intense vertical currents which are associated with thunderstorms and line-squalls, an estimate of the magnitude of the ascending current can be obtained from a consideration of the strength of current required to hold up a hailstone of known diameter in the air during its formation. The strength of the vertical current may be deduced from the following table, which is due to Dr. Simpson.

END VELOCITIES OF HAILSTONES AT 4 KM. (13,000 FEET).

Diameter in inches.	Rate of fall relative to the air ft./sec.
0.5	53
1	75
1.5	92
2	106
3	132

The photograph in Fig. 25 shows some very large hailstones which fell during a thunderstorm at Dallas, Texas, on May 8th, 1926 (12). The estimated diameter of the stones is 2½ inches, which corresponds to a vertical current of about 120 ft./sec. Other noteworthy hailstones of which records are available are the following :—

June 12th, 1919, Branxholme, nr. Teviothead, size of hailstones 2-3 inches; approximate vertical current 120 ft./sec. (13).

May 25th, 1922, Tunbridge Wells, size of hailstones $\frac{3}{4}$in. to 2in.; approximate vertical current 65 to 105 ft./sec. (14).

July 22nd, 1925, Plumstead, size of hailstones as large as a man's fist; vertical current 120 ft./sec. (15).

April 24th, 1930, Baghdad, size of hailstones $1\frac{5}{8}$in.; vertical current 95 ft./sec. (16).

FIG. 25.
Large hailstones at Dallas, Texas, May 8th, 1926.

Information regarding large vertical currents has occasionally been obtained from pilots who have been caught in thunderstorms or line-squalls. Two outstanding examples come from America. In the first an air mail pilot, shortly after leaving Moline Airport for Kansas City on September 10th, 1928, found a thunderstorm approaching and in attempting to circumnavigate it by skirting the north-eastern (front) edge, the aircraft was suddenly thrown out of control and rose rapidly, the altimeter changing from 1,000 feet to 3,500 feet in about 20 seconds. This time was an estimate on the part of the pilot, but assuming that it was correct, the vertical air current in which the aircraft was caught was of the order of 125 ft./min. (17). The second example occurred during the flight of an air mail pilot from Dallas, Texas, to Kansas City (18). The pilot had reached Healdon, Okla., when the aircraft started upwards completely out of control. With the nose pushed down and the engine opened out the machine continued to go up, rising 8,000 feet in 60 seconds, the time in this case being observed by the clock on the instruments board. The upward velocity in this case

was at least 133 ft./sec. It is noteworthy that these strong vertical currrents were observed in the same district as that in which the severe hailstorm occurred on May 8th, 1926.

Coming nearer home, Mr. G. P. Olley, of Imperial Airways, Ltd., was flying a twin-engine Handley-Page from Paris to London on December 31st, 1924, when he encountered a squall near Marden. The story is best told in his own words (19).

" On arriving near Marden at about 14h. 50m. I encountered a severe line-squall, stretching as far as I could see W. to E. (or perhaps W. by S. to E. by N.), so I decided to go through and underneath it. On entering the storm at about 400ft. altitude, I found my machine gradually lifting, and throttled down my engine to obviate this, but without effect.

My machine continued to rise steadily. In the space of about a minute and a half I found myself at an altitude of about 2,800 ft. and came right out on top of the storm, where I received a huge downward bump.

I then carried on above the storm, which was about five miles in width. When in the storm and cloud, I kept the speed of my machine at a little above ordinary cruising speed. On entering the storm I encountered a heavy deluge of rain and hail, but after rising to about 1,800ft. this ceased. The highest parts of the cloud were at about 4,000ft."

Further information is obtained from a report by J. Durward on " Bumpiness in the Cairo-Basra Air Route " (20). During the year October, 1927, to September, 1928, two reports from pilots indicated an involuntary rise, due to an upward current of 4,000 feet in about two minutes or about 33 ft./sec. One of these cases occurred in a thunderstorm on the Gaza-Rutbah section of the route.

As a final example of an up-current measured by a pilot, though not of the same order as those just described, mention may be made of Herr Kronfeld's flight on July 30th, 1929, when, after starting from the Wasserkuppe, he was carried up under a cumulus cloud to 7,000 feet above his starting point, registering an up-current of 16 ft./sec. (21).

5 *Applications to Gliding and Soaring Flight*

(*a*) *Choice of a Gliding Site.*

In choosing a permanent gliding ground considerations will be governed by the ultimate use which is to be made of the site; if it is to be used for training purposes only, requirements will differ from those in regard to a site which is to be used as the starting point for soaring flights. For the latter the ideal site is a ridge of high ground with smooth slopes facing in as many directions as possible. The actual elevation of the ground is of secondary importance to the question of slope. A hill 500 to 700 feet high, or even less, will produce definite up-currents suitable for soaring provided the slope is sufficiently steep. As it is usually difficult to find a site with the right kind of slopes facing in different directions, attention should be given to the frequencies of winds from different directions over the area under consideration, and the main slope should be selected to face the direction of the prevailing wind. Further, as the question of wind speed is of importance, both from the point of view of training and also from that of flying in different types of gliders, the question of the frequencies of different wind speeds from each direction is almost as important as that of the frequencies of different directions. In fact, in a particular case, it might be found desirable to select a slope which did not face towards the prevailing wind direction.

Frequencies of different wind directions and speeds are available for a large number of places in this country. The most convenient way to summarise the information is by means of a " wind rose." A typical wind rose is shown in

Fig. 26. The length of an arrow shows the percentage frequency of the number of observations for which winds from the direction indicated by the arrow have occurred. The single line in any arrow represents, according to the same scale, the proportion of light winds (4-15 m.p.h.), the double line the proportion of moderate and strong winds (16-31 m.p.h.) and the blackened portion the number of gales (32 m.p.h. and over). A scale for obtaining the actual percentage of winds in any particular case is provided by the two concentric circles, the distance between which represents 5 per cent. of the total number of observations. The percentage frequency of winds 0-3 m.p.h. may be written in the inner circle. Such a wind rose gives complete statistical information for a given centre.

The ideal slope for gliding purposes is one of which the length is straight or slightly concave. A narrow hill having a steep cliff-like side to the leeward of the direction which is to be used should be avoided owing to the eddies which may be set up in such a case. If the topography of the reverse side of

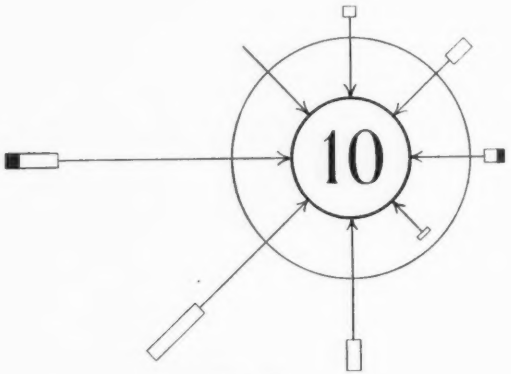


FIG. 26.
A typical wind-rose.

the hill is of this nature, the top of the hill should be of sufficient width to permit landings without entering the dangerous eddy area. This consideration is obviously of fundamental importance in choosing a site for training purposes.

There will be further questions arising from the practical flying and operational points of view, but the foregoing considerations are the main factors which enter into the problem in so far as meteorology is concerned.

(*b*) *Dynamic Soaring.*

This question is, at present, mainly one of theoretical interest but, as indicated by Herr Lippisch in his lecture before this Society on the 29th January last, it should not be disregarded entirely. From the point of view of the flight of birds the subject is a fascinating one, but the attainment of the meteorological conditions which would provide for the man-flown glider what the minor wind fluctuations provide for the bird is a very difficult question. It seems possible that the wave motion referred to in section 3*b* (iv) furnishes the most promising means of utilising the energy provided by varying wind conditions in order to maintain or increase height to any appreciable extent. The matter is one which will have to be investigated much further, both from the theoretical and practical aspects, before a definite answer to the problem can be given.

(*c*) *Auto-towing.*

Experiments in gliding flight have been made recently in which, by using a motor car to tow a glider across a level aerodrome, sufficient forward speed is gained to provide the lift necessary for the glider to rise to an appreciable height in the air. The information available at present suggests that the up-currents which occur near the ground are not sufficiently steady or continuous to permit of their being utilised for soaring flight after the initial elevation of the glider. I should not like to say that it is impossible that the glider could remain aloft on certain isolated occasions, but the requisite conditions do not occur with sufficient regularity to make auto-towing a practicable means to soaring flight. It seems likely, therefore, that the scope of auto-towing will be limited mainly to use for training purposes.

(*d*) *Long-distance Soaring.*

The considerations in the earlier part of this paper suggest at least four possible ways by which long-distance soaring flights may be accomplished. Conditions frequently favour the use of two or more of the suggested methods in conjunction.

(i) Utilising the up-currents along an extensive ridge of high ground perpendicular to the direction of the wind. As such ground is rarely continuous in a form suitable for providing uninterrupted ascending currents, the course for a long flight must be chosen so that sufficient height can be gained initially and maintained throughout the flight to negotiate the areas of down-current eddies and shadow which may occur between the areas of definite up-currents. In selecting a permanent gliding site, the possibility of using the ground as the starting point for long flights of this kind should be taken into consideration.

(ii) Utilising the upward currents under a cumulus cloud to attain sufficient height to glide to the next cloud, then, after rising, to the next and so on, the initial lift being obtained from the up-currents produced by the hill which forms the home gliding centre. Suitable conditions for this type of flight occur, for example, in a north-westerly wind current following the passage of a cold front.

It may not be out of place, perhaps, to point out that the possibility of utilising clouds for soaring was implied, in 1922, in the article referred to at the beginning of this paper. The relevant quotation reads as follows:—

"Another point which has been overlooked is that the strength of the ascending current . . . depends to some extent on the prevailing atmospheric conditions, particularly the vertical temperature gradient. If the lapse rate is large and convection is going on freely, the vertical current will be reinforced. This was observed during the flight of M. Maneyrol, the winning pilot, on the afternoon of the 21st. Heavy banks of cumulus and cumulo-nimbus cloud, which followed one another in quick succession from the north-east, were evidence of strong convectional circulation. The glider was observed to rise appreciably as these passed overhead."

(iii) Utilising the upward current along a coast-line during a sea breeze in summer. The south coast of England is probably the most suitable for this purpose, partly because it is less irregular than the other coasts, partly because the sea breeze frequently reinforces the existing south-westerly circulation and so provides more definite soaring conditions, and partly because along a considerable length of the coast there is high ground which reinforces the upward current.

(iv) Utilising the upward current in advance of a cold front. This method has been used successfully by Herr Kronfeld in Germany. Flights of considerable duration should be practicable by this means.

It should be pointed out that this country is eminently suitable for soaring flights, both circumscribed and of long duration. The topography of the country is almost ideal for the purpose, with its long stretches of downs and, in certain

parts, its mountain ranges. The weather is such that the necessary meteorological conditions for soaring flight occur frequently. There are long stretches of coast-line along which the sea breeze prevails on warm summer afternoons. Further, the meteorological situation is such that cold fronts frequently pass across the country from west to east and thence to the Continent. A long-distance flight starting at a selected point in the south of England and crossing the Channel to the Continent should be feasible by this means.

6 *Suggestions for Further Investigation and Development*

It is perhaps pertinent, at this point, to inquire what is the ultimate end in view in encouraging soaring flight. It has already been pointed out that the development of gliding should lead to an improvement in aircraft design, and we know that the initial interest in gliding in this country was followed very quickly by the design and production of light aeroplanes. It has also been suggested that gliding provides a safe and relatively inexpensive method of flying training, and from this point of view the more that is known about wind currents and the meteorological conditions associated with soaring flight the more useful and complete can a training scheme be made.

The question arises as to whether the sailplane can be used for obtaining useful meteorological data. I have endeavoured in this paper to present a broad outline of our present knowledge of wind structure as affecting soaring flight, but although considerable progress has been made in the last ten years, our knowledge is far from complete, particularly as regards such questions as the detailed air circulation within and around different cloud formations, and the magnitude and extent of vertical currents generally. Such information, besides being of interest for gliding and soaring flight, is of very great importance in connection with the safety of aircraft. It follows that the best means available should be employed in order to investigate these and allied problems more fully. Possible methods which suggest themselves are:—

(*a*) Observations from the ground by means of pilot balloons.
(*b*) The use of free balloons carrying self-recording instruments (registering balloons).
(*c*) The use of power-driven aircraft fitted with suitable instruments.
(*d*) The use of sailplanes suitably equipped.

Pilot balloons have been used for many years, as described earlier in the paper, for obtaining information regarding wind structure. "No lift" balloons, *i.e.*, hydrogen balloons which are in equilibrium in still air, have been used satisfactorily for investigating the wind currents round hills. Mr. C. V. Ockenden of the Meteorological Office has recently devised an ingenious method for releasing a "no lift" balloon at a predetermined height, which should prove of value in determining in greater detail the wind currents at different levels. Registering balloons are used regularly for obtaining temperature and humidity data up to great heights, and power-driven aircraft are also used regularly for obtaining similar information rapidly in connection with daily weather forecasting. The disadvantage of balloons from the point of view of the present discussion is that they travel where the wind carries them and cannot be used for investigating the conditions in the free air at a predetermined point. Further, they do not provide sufficiently detailed information regarding conditions over a small range. Power-driven aircraft can reach a given location quickly, but they cannot remain sufficiently long near one position in order to carry out detailed observations of the kind required. Also, the question of the satisfactory exposure of meteorological instruments on aircraft has, in the past, presented difficulties. The sailplane, on the other hand, suffers from none of these disadvantages, although its use as a possible aid to meteorological research is limited at present to those areas which can be reached by soaring flight. Such areas, however, are

among the more important in which more detailed investigation is required, and from this point of view alone it would appear that the sailplane could be used profitably to obtain interesting and useful meteorological data. By fitting an auxiliary engine to a special sailplane selected for research purposes it should be possible to investigate in some detail other regions of the atmosphere by this means.

Research of the order contemplated needs co-ordination. The means to this end which suggests itself is the establishment of a Central Gliding Research Station on the lines of the Rhon-Rossiten-Gesellschaft. It is beyond the scope of the present paper to develop this idea in detail, but if such a station were established it should be possible to arrange for the various gliding clubs to work in conjunction with it and to draw up a comprehensive programme of investigation which could be worked out in various parts of the country.

Even if it is not possible to attain this ideal immediately, those interested in gliding would do well to keep it before them as a goal towards which to work. Interest in the meteorological problems discussed above and the acquirement and daily use of meteorological knowledge will not only give an added interest and importance to gliding and soaring flight, but will enable those who take up this form of flying to obtain further information which will help meteorology and, through meteorology, aviation.

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Discussion

The Chairman: The Royal Aeronautical Society welcomed this opportunity of meeting jointly with the British Gliding Association. The great importance of meteorology in relation to soaring flight needed no emphasis, and they were particularly grateful to Captain Entwistle for the trouble he had taken in preparing a paper on this subject. It was, perhaps, quite unnecessary to remind the audience that Captain Entwistle had devoted the last 15 years exclusively to the study of meteorology in relation to aviation. He organised the meteorological service for the first commercial air line established between London and Paris; in 1922 he played a very prominent part in the Itford soaring competition.

SIR GILBERT T. WALKER, C.S.I., Sc.D., F.R.S. (Director of the Meteorological Department of the Imperial College of Science): He was particularly pleased with the way in which the lecturer had placed in the forefront the three principles of Lord Rayleigh, which for gliding were largely what Newton's laws of motion were for dynamics. In relation to the third principle, on which dynamic soaring was based, Sir Gilbert remarked that it would remain of theoretical consequence until some practical use was made of it. There was a widespread impression that the effects that could be got out of dynamic soaring were small. To take a practical case, if they imagined a soarer with an angle of descent of four degrees, one in 15, that meant that the acceleration backwards when it was moving horizontally was g divided by 15, or an approximate loss of two feet per second. If a soarer could halve this loss he would be very much better off; and if the air had an acceleration of one he could effect the saving by steering straight into that acceleration. That meant that in three seconds the wind velocity would change by three feet a second, or by two miles an hour. He suggested that a change from five to seven miles an hour in taking three seconds was not abnormally rapid, and as long as such changes occurred one could get out of them something which might be of definite use. At any rate, if his figures were correct, a case was made out for experiments to be made. It was quite true that the effects were not great, but the difference between a man who could make a soaring flight of four kilometres and the man who could make a flight of a hundred kilometres depended on small differences. It was true that we did not see our English birds very often make conspicuous use of dynamic soaring, but anyone who watched the kestrel would be struck by the way in which it seemed to be flying irregularly in different directions, rather like a butterfly; he suggested that that had something to do with the turbulence of the air in which it found itself. He thought they could not afford to neglect any opportunity of learning from birds. In the year 1922 he was watching a train leaving a railway station; great puffs of steam were coming from the locomotive, and a kite came along and described spirals round the ascending columns in order to gain height. In those days Sir Gilbert knew nothing about what they were all familiar with nowadays, or he would have realised that the bird was giving a demonstration of something that was very near cumulus cloud flying.

He was much pleased with the lecturer's division of eddies into small, medium and large. He did not think that in England we realised the power of the sun in producing eddies in the air. At Lindenberg, in July, in the afternoon, the average temperature gradient was 28 per cent. in excess of the adiabatic, or 12.8 degrees a kilometre instead of the usual six or seven degrees. That meant that anywhere near the ground they must have fairly violent up-currents, although they might be small; and at higher levels there must still be moderately strong up-currents, on a bigger scale. Not long ago a soaring feat was performed at the east end of the Baltic, when from a hill of only 50 metres a height of 800 metres was reached. There was no very special meteorological condition there, and we should be able to emulate the feat if we could only get to the ascending column at the base of a cumulus cloud. On the slopes of the South Downs, facing the cool sea, there should, in summer, be the conditions needed, with strong temperature contrasts for producing strong up-currents.

He would associate himself enthusiastically with the lecturer's statement that we must make use of every means we have in this country of getting information from the central institution, which it was hoped would be started before very long, where gliding and power machines, and kites and balloons of every kind should, if possible, be utilised. The essential factors for increasing our information were enthusiasm and determination. There were many things in front of our faces if only we could see them, and the only people who could see them were the men who were anxious to learn.

MR. GORDON ENGLAND (Chairman, British Gliding Association): They were extremely grateful for the help the Society had given the British gliding movement since its inception, and the joint meetings were of extraordinary value to the Association.

There was one thing on which the British Gliding Association could congratulate themselves, namely, that they had had the intelligence and foresight to ask Captain Entwistle to join their Council and to prevail upon him to be the Chairman of their Meteorological Sub-committee.

In the lecturer's reference to gust formations and their regularity he presumed that the lecturer was referring only to where the ground or the sea was of a fairly flat and unobstructed nature, because in the case of a sea with islands in it, or of the ground where there were fields and forests and changes in contour of one kind or another, the gust formations would be irregular. He would like to have some information on that point, because it seemed very important from a gliding point of view. The lecturer had shown them an excellent little diagram of a shed, with the wind blowing over it. He would like to know what happened just above the shed. In his mind, from personal observation and conversation with men like Herr Kronfeld, to those who were attempting soaring flights what happened in the area above the eddy strata near the object was a most important point. He wanted to know more about the steady layer of air above the eddying air which apparently existed on the face of every hill or where there were buildings or obstructions of one kind or another.

He wished that Captain Entwistle had enlarged upon the use of the weather chart for selecting times and places for making soaring flights. It was of tremendous importance, and might interest people to know that Kronfeld had said that it was invaluable. Kronfeld, who had taught him the method, had apparently made a long study of it, and perhaps Captain Entwistle would give them some further information and indicate the possibilities of its use in their week-end operations. He would also like Captain Entwistle to explain the point about the eddies on the windward side of the hill. He noticed that Captain Needham was present. Perhaps he could give them some information as to what happened at Itford Hill, where there was a perfectly good wind blowing up-hill and a perfectly good down-current on the windward side, too. The Californian eddy was a most significant phenomenon, and he presumed that it could take place under similar conditions, though on a smaller scale, in this country; and if that were so it showed not only the gliding pilot, but the aeroplane pilot, the causes of some uncomfortable moments which they experienced in the air.

There was one thing that he hoped would encourage them all to go ahead, namely, that they had now succeeded in reaching the height of their desire in securing, through the good offices of the London Gliding Club, their first " C " certificate by real abilities. They had trained two people to fly a glider, and then to fly a soaring machine, without having had any previous aviation experience. One of those gentlemen, Mr. Humby, was present; he had the distinction, of which no one in the future would be able to deprive him, of being the first man in England to get his " C " certificate entirely through his experience of gliders.

DR. SIMPSON (Director of the Meteorological Office): As the result of invitations from the Society to members of the staff of the Meteorological Office they had had three splendid papers giving the results of meteorological work and investigation, which would not have been put down in writing except for the invitation of the Society. He referred to Mr. Giblett's paper on " Line-squalls," Captain Entwistle's previous paper on " Fog," and his contribution that evening on the atmosphere from the gliding point of view. The paper was a masterly summary of present-day knowledge with regard to the structure of the atmosphere. He had read the paper, and, as most of them were aware, when

one read a paper on one's own subject one felt that certain things could be put in another way; that perhaps they were a little misleading. He could conscientiously say, however, that he had found nothing of the kind in Captain Entwistle's paper. Certain opinions were expressed with regard to the help which gliding could give to meteorology. The speaker did not want to throw cold water on the work of gliding for meteorology, but he asked them not to stress too much the *ad hoc* advantage of that work. That gliding machines would give a great deal of meteorological information there was no doubt whatever. He was quite certain that they could not continue gliding in this or in any other country without meteorologists learning a very great deal from the experiences of gliders, and something which he believed could not be learned in any other way. Therefore he was all out, not only to help but to encourage, and, moreover, to advise the Government to help in the way that had been asked. He was certain that they would get a good return for any money spent in that way, but they must not consider that a glider was a meteorological instrument. Without taking up any more time he would assure all who were interested in gliding, either as a sport or as a training ground for flying, that they would have as complete co-operation as they could wish for from the Meteorological Office. Speaking for himself, as the Director, and, he was sure, for Captain Entwistle, who would have to do the work—which was even more important—they would be prepared to go out of their way to give that co-operation.

Captain Latimer Needham: He was very interested in the lecturer's figures for the average up-current from the measures that were taken. He understood that about 55 per cent. of the up-currents measured were of more than five feet per second. The sinking speed of sailplanes varied from two to three feet per second, so the figures which the lecturer had set out were most encouraging. It would be interesting to know the percentages of up-currents, in excess of five feet per second, in terms of the total observations made. Mr. Gordon England had referred to the fact that two *ab initio* members of the London Club had secured their "C" certificates the previous Saturday. Captain Needham considered that that constituted one of the greatest milestones that the gliding movement had passed since its inception in this country. The first flight was made early in the morning, but owing to various difficulties the second flight was not started until late in the afternoon, by which time the wind had very seriously decreased, and was not more than about ten miles an hour. Time after time it had been noticed that the hour before sunset on a sunny day had peculiarly good soaring qualities. That circumstance was noted both in England and in Germany, and it was for that reason that the second flight was started late in the afternoon, in the hope that the pilot would be able to soar successfully, which he did. It would be helpful if the lecturer could give some information as to why the last hour of daylight should be so good for soaring.

Dr. Thurston: There were in the room that night many experienced and able gliders, who, he thought, would be able to ask very much better questions than he could. He had been very much interested in the lecture, and was particularly glad that reference was made to Lord Rayleigh's wonderful paper in which he set forth the essential qualities of the various forms of gliding flight in a very clear mathematical way. That paper had had an immense influence on the development of aviation, coming as it did before any practical flights had taken place.

Relative to the various air conditions, he remembered on one occasion flying over a cloud formation such as had been shown them that evening, with the long-drawn-out billows, or great rods of cloud with gaps or troughs between. On that occasion, about 13 years ago, the wind was blowing at about 50 miles an hour. They tried to land and saw others doing the same, and several machines turned over in the attempt. They therefore pushed off again above the clouds

and stayed up for two or three hours and saw the sunset above the clouds before coming down. They tried to land several times, but just as the wheels were ready to touch the ground they were suddenly picked up 200 or 300 feet in the air and almost dropped down again on the ground.

A good many experiments had been made with model gliders, and he suggested that a considerable amount of knowledge could be obtained from the models. Had the lecturer made any experiments with models? On several occasions he had seen models launched, and they had continued to glide until they passed out of sight and were lost. As Captain Needham had pointed out, sometimes, when least expected, the model would glide quite well. One advantage which the model possessed over a man glider was that the motor could be fitted with a free wheel propeller which would enable the model to rise to a certain height and then glide when the motor had run out, the propeller then running with little or no head resistance. Why could not a power glider be similarly fitted with a free wheel propeller?

He had been in the tropics, and seen vultures flying from the ground on occasions when there was no wind whatever. Had Captain Entwistle personally made any observations of the state of the air in conditions when soaring flight was so easily obtained by vultures, when there was absolutely no air moving? It was an extraordinarily interesting sight to see those great birds taking off from the ground; they had a struggle to get up into the air two or three feet, but, once they were in the air, they went circling round in a curious fashion with motionless wings, winding round a building or over a bush, but gaining height every moment, so that in a few moments they were 1,000 or 2,000 feet high. He had seen it many times, particularly when it was approaching sunset, which would appear to indicate that perhaps at sunset there was this particular turbulence in the air, or rising current, which enabled the bird to attain height.

It was particularly noticeable in the tropics before the sun went down that a very strong wind came in from the sea, having at certain places a velocity of 40 miles an hour. In Jamaica they called it "the doctor," because it blew the mosquitoes away. It was very strong and powerful, and he would imagine that in the tropical islands very good soaring conditions could be obtained an hour or two in the evening just before sunset. Had Captain Entwistle made any particular observations of the nature of those land and sea breezes which were found on the sea coast? He knew that they had something similar on the coast of Cornwall; he spent some months there, and it seemed to him that during the winter, at least, the wind blew in from the sea as a constant trade wind. If that were so, and that was a common state, he would say that the coast of Cornwall in the winter was an extremely fine and magnificent site for practising gliding.

MR. LANDER: Were the curious spiral currents illustrated on one of the slides due simply to the fact that the air was blowing up a channel, or were they due to excrescences from the sides of the channel?

MR. MANTON: He had come there that evening determined if possible to find out something about up-currents and cumulus clouds. He had asked several people about it, but up to then nobody had been able to tell him. He thought the answer had been provided by the lecturer, that it was not really the presence of up-currents under cumulus clouds as the presence of cumulus clouds on top of up-currents; in other words, that there would be no cumulus clouds if there were no up-currents. He would like to know if that was correct.

MR. BRAMSON: Some time ago, when he had no personal experience of gliding, it struck him that those who were enthusiasts were extremely busy in trying to find an apology for their being so enthusiastic, and were terribly anxious to prove that gliding had some particular use. Now that he had had one or two very modest attempts at gliding he was still of that opinion, and he thought they were

wrong. One should admit frankly that the one great important reason for being keen on gliding was the sheer fascination of it. Why must they always be so concerned to find a scientific and utilitarian reason? He therefore thought that gliding and soaring should be regarded as a sport, probably the most fascinating one that could be invented. One of its uses was that it forced the person who did it to study meteorology, and it was probably a good thing that he could not do any gliding without such study. In that way people would absorb meteorological knowledge who otherwise would not. Moreover, primary gliding and more advanced gliding could be used for training purposes.

DR. WHIPPLE: Many interesting questions had been raised, of which he thought the most interesting to meteorologists was the one as to whether the cumulus cloud made the up-current or whether the up-current made the cumulus cloud. No doubt it was a mutual arrangement; they helped one another. But it was not at all certain exactly how these things came about. He did not know that the glider was the best machine to use for the purpose. They wanted information upon the inside of the cumulus cloud, and if sporting aviators would go through cumulus clouds with thermometers and hygrometers and bring back that information, the meteorologist would be truly grateful. Possibly the glider himself might tell them one thing which would be useful, namely, whether the air just underneath a cumulus cloud was warmer and damper than the air at the same level which was not underneath a cumulus cloud. That information would be very useful indeed. The problem of cloud was something like the problem of the iceberg; they all knew that when they saw an iceberg only a small portion of the ice was sticking out of the water; the greater part was underneath the water and holding it up. Was that what happened in the case of cumulus cloud; was there a mass of warm and damp air underneath the cloud holding it up, or was the air 100 feet below a cumulus cloud a fair sample of its environment?*

Sir Gilbert Walker had not mentioned the very valuable contribution to the subject which had been made by his own laboratory. One of Sir Gilbert's pupils had recently published in Germany an excellent paper describing the sort of turbulence which was produced when unstable fluids were flowing over a flat surface. That paper gave an explanation in terms of turbulence of a phenomenon with which they were very familiar, and which he thought went to the root of gliding, namely, that cumulus clouds—small ones especially—very frequently went in procession; cloud after cloud followed the same route; very frequently in photographs of cloudscape rows of cumulus clouds could be seen at intervals of one, two and four miles. That must be a fact of very great significance to the glider. If he did part of his gliding underneath one cloud and then fell out of the vertical column and he knew where to look for the next column, he was in a much better position. It seemed to Dr. Whipple that according to the experiments in Sir Gilbert's laboratory the glider should stay in the same procession, and should not go across a region of downward air currents to reach another procession.

Another point came home to him when he heard about the favourable conditions for flying in the evening just about sunset. That was the time at which the ground had begun to cool and the air a little above the ground was likely to be warmer than the ground, and was the time at which the eddies nearest the ground were likely to be cooled down. He might mention an experiment which Professor G. I. Taylor had shown him that morning. The Professor had a tank into which flowed streams of water of different density, salt water near the bottom and fresh water near the top. A jet of ink turned into the bottom layer showed no eddies at all, whilst there were quite large eddies in the fresh water near the top of the tank. Dr. Whipple thought that that was a very significant fact

* Dr. Sobhag Mal. "Forms of Stratified Clouds." Beiträge zur Physik der Freien Atmosphäre **17** (1930) 40.

meteorologically, because it showed that the eddies in the atmosphere did not always start at the ground. The conditions which he had described might very well occur in the evening, and be favourable for gliding.

(*Added.*) Until recently it was generally believed that the clouds were buoyant because they were a little warmer than their surroundings. However, two papers, one by K. O. Lange and the other by W. Koppe, in Beiträge zur Physik der freien Atmosphäre (XVI Band, Heft 2, 1930), describe flights in which cumulus clouds were traversed repeatedly, and both investigators found that it was colder inside the cloud than in the air outside at the same level. Both were satisfied that their instruments could be trusted.

Lange (l.c. p. 132) considers that the formation of cumulus reveals the whirling upwards of an air-mass accelerated through the *dynamic* effect of the inflow of cold air near the ground. Whence the cold air comes he does not state. On the other hand Koppe follows Robitzsch in supposing that the air inside the cloud is buoyant on account of a very large proportion of water vapour, 500 per cent. of that needed for saturation!

The explanation which the speaker would suggest for the phenomenon is that the buoyancy is to be found in the air, humid and warm, below the clouds. The clouds are cooled on the outside by radiation and evaporation. The air which settles down between them may be warmer than the clouds at their own level, but as it falls lower a height is reached at which this descending air is cooler than the air bringing up the clouds.

To test the theory special observations are necessary.

MR. MANNING: Is the effect of the severe up-current mentioned by the lecturer known from the point of view of producing accelerations on the aircraft? As far as he knew, a vertical acceleration of 1½g. was the highest that had ever been measured as due to bumps and not controls, but it seemed probable that the severe up-currents mentioned by the lecturer would produce an acceleration greater than this figure. The question was of considerable importance from the point of view of stresses.

COMMANDER COLSON: Might not a bump striking the underside of a glider when it was being towed create a dangerous position, since the gliders would be held down by the car? He would be glad if Captain Entwistle could tell them the effect of a steady downpour of rain on the turbulence of the air; for instance, if it occurred during the middle of a soaring flight would it immediately affect the actual conditions with regard to flying or only gradually so?

MR. F. JONES: Does the lecturer attach any importance to the better flow of air over a surface when the temperature is raised?

MR. ASHWELL-COOKE: One point struck him very forcibly as a spectator during the recent soaring flights at Tottenhoe. On two or three occasions when they appeared to have more or less constant conditions, with the wind direction almost at right angles to the summit of the hill, the experience of pilots of similar capabilities seemed to demonstrate that the width of the particular range of up-current varied considerably. He would like to know whether in fact that was the case or whether it was purely and simply a question of differences in the skill of the pilots.

MR. THURSTAN JAMES (Editor, *Sailplane*): The suggestion had been made that gliders should be fitted with engines and air screws to enable them to gain height. He understood that quite a lot of work had been done on those lines in Germany, and it had been found that the fitting of an engine and air screw reduced the efficiency of the machine, and prevented any really valuable results being obtained. Something had been said that night about towed gliding. He believed that experiments were afoot to tow sailplanes behind aeroplanes. Did Captain Entwistle think there were any possibilities in that method of exploring air currents with a sailplane which could be released at any pre-determined spot by the pilot of a power machine?

The suggestion had been mooted that a central research organisation should be formed. All over the country gliding clubs had been formed. There was a great deal of enthusiasm but very little knowledge. Captain Entwistle might be able to formulate some scheme whereby those clubs might be able to contribute their small quota of knowledge to the general stock. He might outline the simplest equipment that they would need and the research and observation that they would have to carry out. In that way, by doing a little regular work on the subject, the clubs might improve their knowledge of meteorology, of which at present most of them knew very little.

The CHAIRMAN: While listening to the interesting discussion that had taken place he had noticed that there was some confusion of thought in regard to the use of the words "gliding" and "soaring." Speakers kept on referring to gliders and gliding when they meant sailplanes and soaring. It was very necessary to differentiate clearly between the elementary stage—gliding—and the final stage—soaring.

He would like to ask Captain Entwistle at what height cumulus clouds might normally be expected in England. In America, with the help of auto-towing, sailplanes had been towed up to 1,500ft., and he presumed it might be possible in this country to make cloud flights after attaining such an altitude.

The towing of sailplanes by aeroplanes had been mentioned, and it seemed certain that such a method could be employed very usefully for research purposes. The sailplane certainly appeared to offer considerable possibilities for meteorological research, and he would like to ask the lecturer as to whether such a machine was not more useful—particularly for research in relation to cloud formations—than a power driven machine.

He had not noticed in the Paper any definite reference to the different conditions that would be encountered in the winter and in the summer. It was common knowledge that at the Wasserkuppe it was possible to soar in comparatively light winds in the summer, but that in the winter an increase in velocity of perhaps 50 per cent. or more would be required before soaring would be possible. It was obviously essential to study carefully the thermic conditions.

The remarks that had been made by Dr. Simpson, the Director of the Meteorological Office, were very much to the point and everyone would feel inspired by the Director's pronouncement that he was going to use every means in his power to forward the movement. If Dr. Simpson was able to facilitate this in a practical way by financial grants for research work they should find it difficult to show their real appreciation.

As the years went by those interested in aviation became more and more indebted to people like Captain Entwistle, who, as Dr. Simpson had been careful to explain, was directly responsible for an important section of the work of the Meteorological Office. No one had ever attempted an aeroplane flight, other than one of a local character, without first consulting Captain Entwistle or his department. Everyone had received the most courteous and detailed assistance at the hands of the lecturer, and he (the Chairman) felt sure that the same remarks would apply in even greater force to the sailplane pilot.

REPLY TO DISCUSSION

A number of interesting points has been raised in the discussion, but I am afraid that further investigation will be required before certain of them can be answered fully and definitely.

I was extremely interested in Sir Gilbert Walker's remarks regarding dynamic soaring. As I indicated in the Paper, I do not think that the matter is one which should be disregarded entirely, but I do think one must recognise that there comes a point at which the analogy between bird flight and the flight of a man-flown sailplane ceases; it is really a question of scale, and that is why I emphasised

the existence of a scale difference between the various kinds of disturbance which occur in the atmosphere. In any case, we must all be agreed that the first step to aim at is proficiency in soaring flight, making use of the large-scale upward currents which we know to exist and which we know to be effective in supporting a sailplane. The possibility of dynamic soaring may be investigated at a later stage.

Several questions referred to the mechanism of eddies which occur in different conditions. Mr. Gordon England referred to the regularity of eddies. The point in the slide shown at the beginning of the lecture was the individuality rather than the regularity of the eddies. Naturally over a level surface they would tend to maintain their character unchanged for a longer period than in the case of air flowing over a broken surface. Mr. Gordon England also raised a point about the eddies over the shed. The slide showed a surface of separation between the lower turbulent layer, due to the obstruction of the shed, and the steady layer above. The position of the boundary between the two layers would vary with the nature of the obstruction, the direction and strength of the wind and the temperature lapse rate. With regard to the eddies on the windward side of a hill, there is no doubt that in certain conditions, particularly if the slope is steep, a down current could occur on the windward side close to the hill, but further observations would be required before the question could be answered definitely. The eddy of the California type could certainly be reproduced in this country under suitable conditions. Such an eddy would be induced mainly by the warming of the side of the valley on a sunny afternoon when the wind was blowing directly up the valley, although it might also be assisted by the topography of the valley.

It is a little difficult without further information to picture the exact conditions on the day to which Dr. Thurston referred. With a wind of 50 miles per hour, conditions would be extremely turbulent, and landing an aeroplane in such a wind would be difficult in any case. It is probable that, in addition to the strong wind, there existed special turbulent conditions to which the peculiar cloud formation described by Dr. Thurston was due. I agree with Dr. Thurston that much may be learned from experiments with models, although I should expect such experiments to be more valuable from the design than from the meteorological point of view. With regard to the flight of vultures on calm days in the tropics, the steep temperature lapse rate—due to intense surface heating—would be favourable for strong upward currents. Such conditions are frequent in hot countries in the daytime and would be sufficient to provide the necessary support for the soaring of birds.

A distinction has to be drawn between the sea breezes of hot weather which are associated with upward currents along the coast, due to the temperature difference between sea and land, and winds which blow from sea to land in winter as a result of the horizontal pressure gradient. The prevailing south-west winds on the Cornwall coast in winter belong to the latter category, and would not be associated with upward currents unless there were high ground running normal to the wind direction.

Commander Colson raised an interesting point in regard to the possibility of a glider being struck by a bump while it was being towed. This might easily occur if auto-towing were carried out in a strong, squally wind and would certainly constitute a danger. With regard to the effect of rain on the turbulence of the air, in the conditions in which a soaring flight could be made, there would be a definite up-current. Heavy rain would not fall from the part of the cloud where the up-current was strongest. Therefore the sailplane would be out of the main ascending current if it were caught in the rain and would be affected immediately. In the case of soaring on the windward side of a hill, the effect of rain would be slight.

Captain Needham raised an interesting point in regard to the suitability of evening conditions for soaring, which has been answered partially by Dr. Whipple.

By evening, surface turbulence has died down, while the general temperature lapse rate—which is favourable for an upward circulation—differs but little from that which existed earlier in the afternoon, except close to the ground. Thus for an hour or two round about sunset much steadier soaring conditions might be expected. The Chairman referred to the difference between summer and winter conditions. The topographical effect and the thermal effect are, to some extent, interdependent, as was pointed out in connection with the Itford Hill contest. There is no doubt that, on the average, soaring conditions in the neighbourhood of a hill are much better in summer than in winter. The actual soaring conditions on two separate days may be quite different, even if the wind direction and strength is the same on the two days. This answers the point raised by Mr. Ashwell Cooke.

It was not unnatural that attention should be focussed in the discussion on the mechanism of cumulus clouds and their relation to upward currents, and Dr. Whipple has given some very interesting information in this connection. I think that this is a subject on which we may look to sailplane pilots to provide us with further information. Referring to the point raised by the Chairman in regard to auto-towing, if it were possible to get the sailplane up to 1,500 feet there would certainly be occasions on which it would reach a definite upward current, but, speaking generally, I doubt whether the up-current found under a cumulus cloud would become effective much below 2,000 feet. I speak, however, subject to correction and to further investigation.

Both the Chairman and Mr. Thurstan James referred to the towing of sailplanes by aeroplanes. There is no doubt that when this method of towed flight is perfected it will provide a ready means by which a sailplane may be taken to any point at which it is desired to carry out investigations. The use of the sailplane as an instrument of meteorological research will then be greatly enhanced. Also the necessity of finding a suitable hill for the commencement of a soaring flight will be obviated, since the sailplane will be able to start from an aerodrome.*

In reply to Captain Needham's question regarding the magnitudes of up-currents, the figures quoted were based on an examination of 2,040 pilot balloon ascents. Upward currents of 5 ft./sec. or over were thus observed on approximately seven per cent. of occasions. These figures, however, must not be taken too literally, as the method of observation does not give very definite information regarding the extent of the upward current.

Mr. Manning's point is an extremely important one, but, in order to answer it, it would be necessary that the aircraft should be fitted with an accelerometer. So far as I am aware there are at present no data giving this information; all that is available is the mean upward current over a given range.

I am glad that Mr. Bramson regards gliding and soaring flight as a means to acquiring a greater knowledge of meteorology. Even if he does not care to go beyond that, he will probably agree that meteorology as a science cannot but gain thereby. If any advance is to be made in soaring, meteorological knowledge is essential. It is essential to pilots of power-driven aircraft, though from rather a different point of view, but nobody can expect to make progress in soaring flight unless they study meteorology seriously, since ability to soar depends on making use of knowledge of air currents. During the last few months I have had the privilege of collaborating with Herr Kronfeld and Herr Lippisch, and I have been very much impressed by their meteorological knowledge. It is typical of the thoroughness with which the gliding movement is being pursued in Germany.

* Since this lecture was delivered, the towing of sailplanes by aeroplanes has passed the experimental stage in Germany and is now regarded in that country as a safe and reliable method of launching. On May 5th, 1931, a sailplane piloted by Herr Groenhoff took off from Munich Aerodrome, towed by an aeroplane, and after release carried out a soaring flight of 265 kilometres in front of a line squall, landing at Kadden (Czecho-Slovakia) after a flight of eight and a half hours.

Mr. Gordon England has referred to the use of the weather chart. The weather chart is the basis of modern forecasting, and much may be learned from a study of current charts as to the winds to be expected over given areas for gliding and soaring operations and the areas where upward currents may be found. I cannot go further than that at the present time—a whole lecture would be necessary to discuss the subject adequately—but I would emphasise that the study of weather charts should find a place in the meteorological curriculum of all who are taking up gliding and soaring seriously. That brings me to the point raised by Mr. Thurstan James. The Meteorological and Sites Sub-Committee of the Technical Committee of the British Gliding Association has been formed in order to advise on meteorological questions, and it is hoped to draw up a course of study in meteorology for gliding and soaring pilots and also to indicate different ways in which the various gliding clubs may co-operate in meteorological work in connection both with the investigation of sites and with soaring.

I need hardly say that I associate myself entirely with Dr. Simpson's remark as to our desire to do everything we can to help the movement. We may not regard the sailplane altogether as a meteorological instrument, but the more soaring is approached scientifically, and meteorological knowledge acquired and used, the greater will be the usefulness of soaring flight from the purely meteorological point of view.

In conclusion, I should like to express my thanks for the reception which has been given to this Paper and my indebtedness to the Royal Aeronautical Society and to the British Gliding Association for having done me the honour of asking me to read it.

PROCEEDINGS

Fifth Meeting, Second Half, 66th Session

The Fifth Meeting of the Second Half of the 66th Session of the Royal Aeronautical Society was held at the Royal Society of Arts, Adelphi, W.C.2, on Thursday, 12th March, 1931, at 6.30 p.m., Mr. C. R. Fairey (the President) in the chair, to hear a Paper, entitled "Night Air Mails," by Captain Carl Florman (Managing Director of the A.B. Aerotransport, Stockholm).

The President: They were there to listen to a lecture on the most interesting subject of "Night Air Mails," by the Managing Director of one of the few companies in Europe which had actually run such a service. Captain Florman was a pioneer of aviation. He joined the Swedish Royal Air Force as long ago at 1914. By 1917 he was in command of the Swedish Royal Flying Corps in the Lapland area, and in 1922 was appointed the first Air Attaché from Sweden to this country. In 1924 he formed the A.B. Aerotransport Company of Sweden, which now had a monopoly of civil flying in that country. The company not only ran its regular services but the night air mail transport service, which Captain Florman would describe to them. The efficiency of the company was indicated by the fact that they had carried 78,000 passengers without any sort of accident or injury to anybody.

NIGHT AIR MAILS

BY

CAPTAIN CARL FLORMAN

(Managing Director of the A.B. Aerotransport, Stockholm)

The work for the development of air traffic in Europe into a generally recognised means of communication in conjunction with railways and steamships, has hitherto mainly been done through the conveyance of passengers and goods. Mail has certainly been carried by the aeroplanes, but as a rule only in small quantities. As managing director of the Aerotransport Company, the Swedish Air Line, I have seen this development with a certain amount of worry and distrust, and submitted therefore to the International Air Traffic Association a suggestion for organising, at the earliest possible moment, a general European air mail net, mainly for night traffic. My suggestion was dealt with by a Committee appointed at the Iata's last session in Antwerp, and the suggestion was discussed also at the Postal Congress which was held at Brussels in October, 1930.

I realise that the question of establishing air mail conveyance between London and the various parts of the Empire is of great importance from a British point of view, but as this object has nothing to do with the aims for which I am working, I shall not touch upon it to-day. The air mail lines to the different parts of the Empire will have to be organised on quite different lines, and run in quite a different way from those which will have to be established in Europe, for which reason these two questions have nothing in common.

I shall begin by giving a brief synopsis of the present night air mail traffic in Europe and its organisation.

Germany

The Deutsche Luft Hansa began night air mail flying in a trial attempt during 1926, when the line Berlin-Danzig-Königsberg was operated for five months and a total number of 503 trips were made. These night air mail flights have since been continued and have increased every year, and last year night flying was carried on over the following lines:—

1. Königsberg-Danzig-Berlin.
2. Berlin-Hanover-Cologne-London.
3. Stralsund-Stockholm.
4. Malmoe-Hanover-Amsterdam.
5. Leipzig-Berlin.

Altogether the Deutsche Luft Hansa covered 764,838 kilometres last year (1930), representing 2,014 night trips, in the course of which 83,510 kg. of mail was carried. Regularity averaged 90.1 per cent.

During the present year approximately the same lines will be covered during the night, the season lasting from April 1st to October 1st. The line between Berlin and Hanover will, however, also be operated all the winter.

Belgium

The Belgian Air Traffic Company, Sabena, has since April 14th, 1930, been operating the line between Brussels and London at night. This traffic is subsidised by the Belgian State, and is intended for the conveyance of the entire Belgian night mail to England, and practically all this mail is carried without any air fee. The departures are 11.30 p.m. from Brussels and 2.30 a.m. from London. The average weight of mail for each trip from Brussels is 176lbs., but that from London, on the other hand, is only 9lbs.

REPORT OF SABENA

NIGHT AIR MAIL LINE BRUSSELS-LONDON.

April 14th, 1930—Jan. 31st, 1931.

Month.	Trips planned.	Trips completed.	Trips not completed.	Punctuality in per cent.
1930.				
April	All trips completed.			100.00
May	,,	,,		100.00
June	,,	,,		100.00
July	,,	,,		100.00
August	41	39	2	95.12
September ...	44	37	7	84.09
October ...	44	38	6	86.36
November ...	38	26	12	68.42
December ...	40	13	27	32.50
1931.				
January	42	22	20	52.38

The regularity in summer time was perfect, *i.e.*, 100 per cent., but poorer during winter. Nevertheless, the Belgian company is worthy of all honour for this remarkable pioneering work, and it is not to be wondered at, the first winter, before the company's pilots had yet sufficient training in night flying, that the regularity has not been so great. One may, however, assume that the company's night air mail service will gradually grow better, and will soon, from a postal

point of view, attain satisfactory regularity, though the line in question on account of fogs presents exceptional difficulties.

Scandinavia

During the year 1928 the Swedish Post Office in co-operation with the Aerotransport Company arranged for eight trial night mail flights between Stockholm and London. The aeroplane was fitted as a mail van, and a postal official accompanied the same and sorted the mail on the way. This was done for the purpose of gaining experience and to see if the sorting of mail could advantageously be done during the flight. The route followed was Stockholm-Malmoe-Hamburg-Amsterdam-London. The trials carried out gave us encouragement to continue the work for establishing night air mail routes from the Scandinavian countries, and in order to bring about co-operation between the Northern countries in this matter, the Danish Post Office issued invitations for the first Scandinavian Night Air Mail Conference in Copenhagen, on February 7th, 1929. It was then resolved to arrange jointly a one month's night air mail service on the lines Stockholm-Copenhagen-Amsterdam-London and Oslo-Gothenburg, Copenhagen-Berlin on six nights a week during the summer of 1929. The flights, which were made by the Scandinavian Air Traffic Companies and the Deutsche Luft Hansa and the Dutch Company Koninklijke Luchvaart Maatschappij jointly, turned out well. In 1930 these trials were further extended and were kept up for two months. It is intended during the current year to establish a four months' night air mail service. The time-table for this year will be as follows:—

TIME-TABLE (CENTRAL EUROPEAN TIME).

16.00	dep.	Helsingfors	arr.	12.45
18.45	arr.	Stockholm	dep.	10.00
20.00	dep.	Stockholm	arr.	8.55
24.00	arr.	Copenhagen	dep.	5.10
10.00	dep.	Oslo	arr.	9.20
21.20	dep.	Gothenburg	arr.	7.00
23.30	arr.	Copenhagen	dep.	4.45
1.00	dep.	Copenhagen	arr.	4.18
4.00	arr.	Hanover	dep.	1.30
4.30	dep.	Hanover	arr.	1.00
6.50	arr.	Amsterdam	dep.	22.40
8.40	dep.	Amsterdam	arr.	22.00
11.55	arr.	London	dep.	19.00
12.30	arr.	Paris	dep.	15.00
6.00	arr.	Berlin	dep.	22.00

The payment for the conveyance of mail has been made in such a manner that the Post Offices in the Scandinavian countries, Denmark, Finland, Norway, and Sweden, together guaranteed payment according to the so-called Hague Convention for 1,200lbs. of mail for each west bound trip as far as Amsterdam, where the night air mail 'planes handed over their mail for conveyance to its destination by the Kim's ordinary morning machines to London, Brussels and Paris.

I mentioned that the Scandinavian Post Offices contribute sums according to the Hague Convention, whereby the payment should be at the rate of 6 gold centimes per 100 grammes and 100 kilometres. That the Post Offices were able to guarantee for such a large weight as 1,200 lbs. per trip, is due to the fact that

a start has been made to send *all* first-class mail, *e.g.*, even such for which no air fee has been paid, by the night air mail service. The actual weight was thus almost what was guaranteed. There can, therefore, in this respect not be any suggestion of any mail subsidy, but merely of payment according to an internationally-fixed tariff for work done.

France

Last year the Compagnie Internationale de Navigation Aérienne (Cidna) maintained a night service from April 1st to December 1st on the routes Paris-Strassburg and Belgrade-Bukarest. The regularity between Paris and Strassburg was between 97 and 100 per cent. during the summer season and about 75 per cent. in the winter months. Between Belgrade and Bukarest the regularity was still better. The Company's night flights were carried out entirely with three-engined machines. The Air Union for shorter periods during 1926 and 1927 carried out trial night flights between Paris and London. When the beacon illumination along the route had been arranged more satisfactorily, the

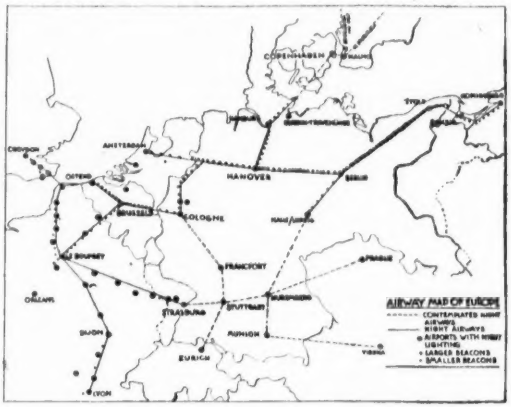

FIG. 1.

Company commenced a regular night service on the 9th April, 1929, and this was continued uninterruptedly until the 7th September last year. During 1929 and 1930 397 flights in all have been carried out; 425 flights were intended, so that the regularity has thus been on an average no less than 93 per cent.

Lighted Airways

I shall now show Fig. 1, a diagram of the present European night air routes equipped with beacons and emergency landing places. We see from it that there exists already a long route illuminated by beacons along the whole length, namely, London-Brussels-Cologne-Hanover-Berlin-Danzig-Koenigsberg and another line from London via Paris-Dijon-Lyons to Marseilles. Furthermore we have the lines Paris-Brussels, Paris-Strassburg, Amsterdam-Hanover, Hanover-Hamburg-Danish Frontier, as well as Berlin-Leipzig.

The line Strassburg-Nuremburg-Prague-Vienna will be lighted for the French company Cidna; further, lighting is planned from Frankfort to Cologne, from Munich to Halle, Leipzig, and from the German frontier to Copenhagen and Stockholm, as well as from Copenhagen to Gothenburg and Oslo.

We are thus already able to discern in the completed night airways the main outlines of how the future night air mail routes in Europe will look.

After this account of its present state in Europe, I wish to pass on and say a few words about the night air mail service in the United States.

As you are probably aware, the air mail service in America was at the beginning operated entirely by the Post Office. A departure from this system was made subsequently, and now the mail is carried by the various airways companies under contracts, which have been entered into between the Postmaster-General and the respective companies. In order to supply an instructive illustration of the present American air mail service, the following figures may be quoted:—

PROGRESS OF UNITED STATES AIR MAIL IN STATISTICS

	1926.	1927.	1928.	1929.	First six m'ths 1930.
Total mail carried, lbs....	810,855	1,654,165	4,063,173	7,772,014	6,596,475
Mail carried by contract, lbs.	377,206	1,270,209	4,963,173	7,772,014	6,596,475
Mail income to contractors, $	765,549	2,643,454	7,432,721	17,042,521	—
Miles of mail airways Dec. 31st	8,039	7,832	14,561	26,597	—
Average mail load in lbs. per scheduled round trip	112	273	489	617	620
Average income per lb. of contract mail, $ ...	2.03	2.08	2.03	2.01	—
Average mail income per contract mile flown, $	0.39	0.625	0.94	—	0.85
Number of mail operators Dec. 31st... ...	15	16	21	22	—
Airplane miles flown with mail	4,240,407	5,543,578	7,846,296	14,869,166	—
Miles lighted airways Dec. 31st	2,041	4,468	6,988	12,448	—
Electric and gas beacons Dec 31st	612	760	1,188	1,311	—
Lighted intermediate fields Dec. 31st	[illegible]	134	210	285	—

Fig. 2 shows a chart of all the lighted American airways in December, 1930. In December, 1926, 12,448 miles were illuminated, and since then the figure has risen to over 14,700 miles.

I am unable for the moment to give any typical contract between the United States Post Office and the airways companies, because no standard contract is in use, each arrangement being drawn up in a separate form with suitable terms for the needs of the particular route. Nevertheless, it might be interesting to know one of the most recent. A contract awarded to the Pan-American Airways Inc., of New York City, is an agreement for carrying mail by air from Dutch Guinea to Santos, in Brazil, a distance of approximately 3,275 miles each way. The concern is to receive $2 a mile each way for carrying the mail over this route for a specified load not exceeding 800 lbs. plus a rate of $1 a pound per 1,000 miles for any excess mail required to be carried. The service is to be a weekly one, and the contract will run from October 20th, 1930, to January 8th, 1939.

Fig. 3 shows air mail operation statistics in the United States, January to June, inclusive:—Miles of service scheduled, 8,202,670; actually flown,

7,542,416; average revenue per scheduled mile, $0.85, and the total monthly air mail poundage for the United States from January, 1929, to June, 1930 (inclusive).

We see from the illustration that the quantity of mail was much greater during the six summer months, which was chiefly due to poorer regularity in winter, but we also notice that the winter mail has largely increased in 1930, compared to 1929.

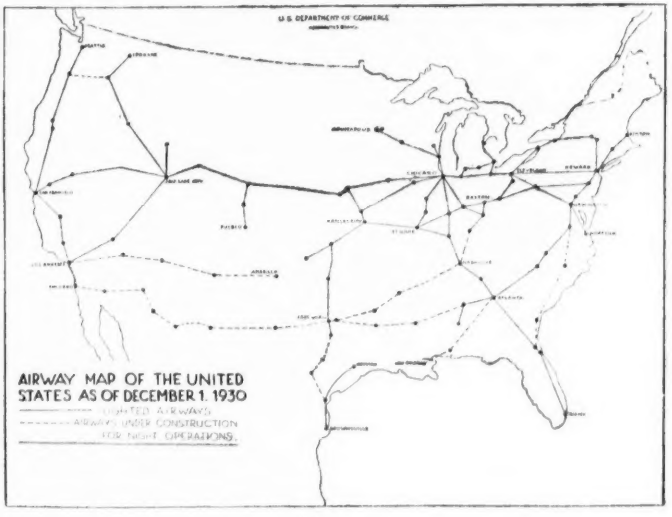
U.S. DEPARTMENT OF COMMERCE
AIRWAY MAP OF THE UNITED STATES AS OF DECEMBER 1, 1930
AIRWAYS
AIRWAYS UNDER CONSTRUCTION
FOR NIGHT OPERATIONS

FIG. 2.

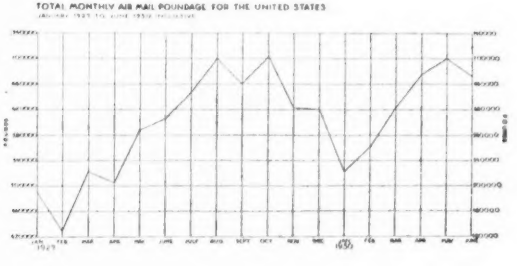

FIG. 3.

If we examine the average revenue which the American airways companies received last year per mile, at the rate of payment under the Hague Convention for European air mail service, we shall arrive at the following figures :—

U.S.A.	*Europe.*
Average Revenue per mile. $0.85 = 4.4 gold francs for an average weight of mail of 620 lbs. per trip during 1930. This constitutes an average revenue of 0.7 gold centimes per lb. and mile.	*Revenue under Hague Convention.* Per kg. and 1,000 kilometres = 6 gold francs, which is equivalent to approximately 0.5 gold centimes per lb. and mile.

It is thus proved that the payment received by the European airways companies is lower than that received in the United States, although the airways companies there possess the advantage of getting much bigger quantities of mail.

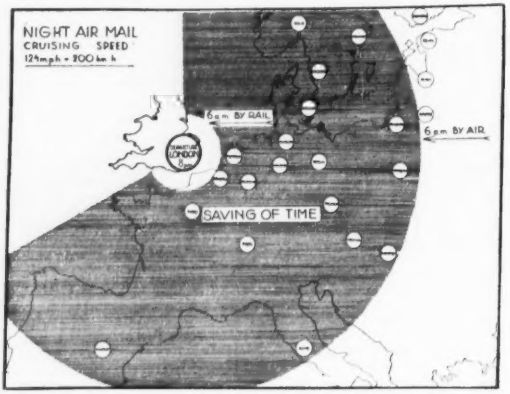

FIG. 4.

Future Night Air Mail Service in Europe

After this account of the present situation in Europe and the United States with regard to air mail service, I shall pass on to a scrutiny of the problem regarding the near future, and its prospects of development for night air mail service in Europe.

In order to explain the question from a British point of view, I shall first show a map (Fig. 4), from which it will be clear what distances mail planes from London are theoretically able to reach in the course of the night with an estimated speed of 124 miles per hour = 200 kilometres per hour. I have called the map theoretical, because any possible landings at intermediate stations have not been taken into account.

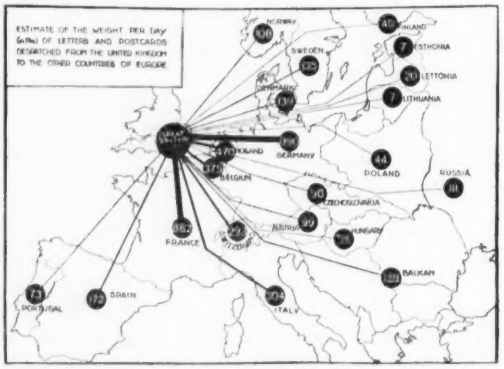

FIG. 5.

In Fig. 5 I have graphically marked with different thick lines and figures in pounds the quantities per day of all outgoing first-class mail (letters and postcards) from England to various countries in Europe. From these

figures it will be seen that the weights of first-class mail from England are no greater than the whole amount which might be conveyed by aeroplanes, although all first-class mail has here been included, *e.g.*, even that for which a separate air fee has not been paid. The figures are calculated on the basis of international postal statistics.

It will also be seen from the map that the quantities of mail to certain countries are so trifling that a separate air mail line to such a country cannot be thought of, as it would not pay.

It is not impossible to convey this mail in the course of a night from England to practically the whole of Europe.

In order to demonstrate clearly and in detail the saving of time by conveying the mail by air during the night from London, I have, however, drawn up a separate map (Fig. 6). We see from this that mail conveyed by a train, leaving

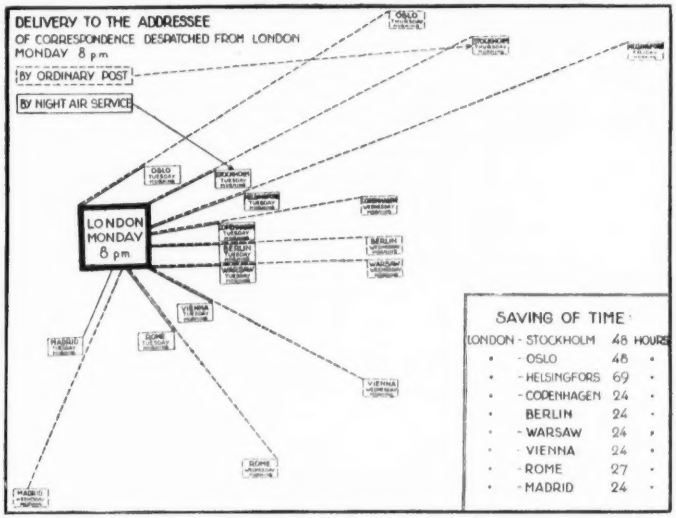

FIG. 6.

London, let us say, on a Monday night, is not delivered in Helsingfors until the Friday morning, in Stockholm and Oslo on Thursday morning, and in Copenhagen, Berlin, Warsaw, Vienna, Rome, and Madrid on the Wednesday morning, whereas the same mail, if it were forwarded by night air mail from London, could be delivered at all these places by Tuesday morning. What this would mean to English commerce and industry, if equally good postal communications were obtained by her with distant European countries such as we now have with our next-door neighbours, is perfectly obvious. England would in this way get just as good postal communications with, *e.g.*, the Scandinavian countries, as Germany now has with them. A letter posted in Berlin on Monday evening reaches Stockholm by night air mail on Tuesday morning, enabling a reply to be received on Wednesday morning! A letter posted in London on Monday evening, and despatched by rail, is not delivered in Stockholm until Thursday morning, and the reply does not reach London until Saturday evening, and is as a rule not delivered before Monday morning. The business man in Berlin thus gets his reply from Stockholm after 36 hours, whereas a business man in London requires a week to get an answer from Stockholm. This is the case if no night air mail service is established from London.

But even the British postal connections with the neighbouring countries of France and Belgium, will gain considerably through night air mail service. Mail dispatched by train leaves, as we know, at 10.30 a.m., and can, therefore, not be delivered until after lunch. In view of the lively and intimate business relations which exist between these large capitals, the improvement in the exchange of mail, which will be gained by the night air mail services, is of great value and importance.

By establishing a night air mail service as well on the line Paris-Marseilles improved postal connections are furthermore obtained between London and the Riviera, as well as between London and the long-distance mail boats to and from Marseilles.

The night air mail service is of great importance for the exchange of mail between London and Belgium.

I consider that the question relating to the establishment of a regular night air mail service in Europe, throughout the year, it is of the utmost importance for attaining better intercourse, both cultural and commercial, between the European countries. Hitherto this intercourse has been satisfactory between adjoining or neighbouring countries, but on the other hand the intercourse between more distant countries has been far from animated.

The British Post Office will, therefore, reap the greatest benefit by assisting the correspondents in attaining such improved communications as the establishment of a night air mail to the Continent would carry in its train.

Even for the air lines companies the organisation and establishment of such air mail service may become of the utmost importance since the conveyance of mail is from an economic point of view, the most paying part of the business. Besides, the air line companies will get an opportunity through night air mail service to demonstrate to the nations what an actual valuable asset a well-organised air mail service really is,

In order to make the night air mail service pay as far as possible, and in order to gain the utmost possible benefit, it will, however, be necessary for the work to be arranged on international lines, and to bring about this by intimate co-operation not only between the air line companies and the Post Offices, but also mutually between the same.

It will be a case of trying to establish and enlarge a night air mail net *which, with the smallest number of miles flown, gives the best economic and practical results.*

How then will a European air mail net have to be established in order to produce the biggest saving of time with the least possible economic sacrifice?

Such a European night air mail net must in the first instance secure and safeguard the intercourse between the three largest, and, from a commercial point of view, most important cities, viz., London, Paris and Berlin. To this triangle will then have to be connected up other important cities and towns by intermediate landings, or by joining them up with air lines. Futhermore, in organising a night air mail service use should first and foremost be made of already established and completely lighted air lines, as I demonstrated in a previous illustration.

I now take the liberty to submit a map of Europe (Fig. 7), on which I have set out the night air mail service as I imagined it should be organised in its first stage of development.

The thick black lines indicate the main routes, which are bound to find a place in the scheme and are also already being operated at any rate during a certain part of the year. The line Berlin-London passes through Cologne not only for the purpose of being able simultaneously to carry the mail to Paris, but also to exchange the mail with Western Germany.

The line runs in an arc along to the Dutch frontier so as to avoid the troublesome Teutoburger Forest between Hanover and Cologne.

The other lines drawn in black show junctural night air mail routes, which I consider should be established in the first instance; these are:—

Marseilles-Paris.
Basle-Frankfort-Cologne.
Warsaw-Berlin.
Koenigsberg-Berlin.
Stockholm-Copenhagen-Hanover.
Oslo-Gothenburg-Copenhagen.

Ultimately, the lines drawn with dashes show some of the junctural day routes. These will, as a matter of course, become more numerous in future, but I have only included the most important ones, *e.g.*:—

Madrid-Barcelona.
Barcelona-Marseilles.
Naples-Rome-Genoa-Marseilles.
Moscow-Koenigsberg.
Riga-Koenigsberg.
Leningrad-Helsingfors-Stockholm.

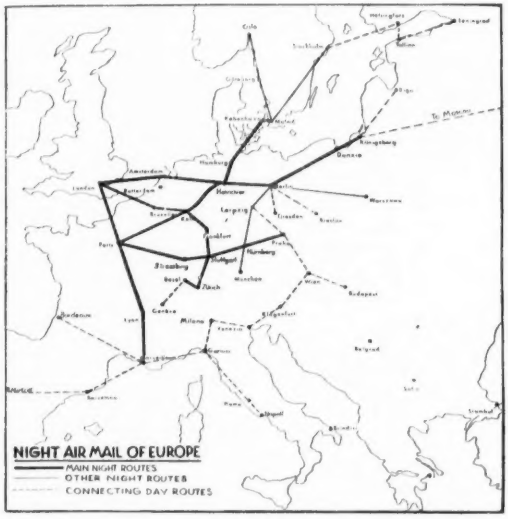

FIG. 7.

A good many of these lines will undoubtedly in the future also be operated at night. If we study this map somewhat more closely, we shall see that the traffic from northern and eastern Europe has been run together into a main artery via Hanover and Cologne to London and Paris, whereas the traffic from southern Europe and the most important ports on the Mediterranean would be run via Paris. Finally, the mail from Central Europe, *e.g.*, from South Germany, Switzerland, Czeckoslovakia, Austria, and several other countries, will reach London either via Nuremberg-Strassburg or via Cologne. The mail from Belgium would, as hitherto, be conveyed by the night air mail route from Brussels to London and from Brussels to Cologne for transit to and via Berlin, while the Dutch mail would possibly connect up with separate night air mail 'planes from Amsterdam to London and Amsterdam to Hanover.

The night air mail net I have suggested will, as can be seen, utilise all lighted airways which exist already in Europe.

How may we then assume that the night air mail service suggested here would be distributed between the airways companies of the various countries, and how might the economical question be settled and secured?

The principle adopted should be that the night air mail flights should, if possible, be carried out in co-operation between the airways companies in those countries which are directly concerned. Furthermore, I have, in the suggestion for the distribution of the traffic which I am now submitting in regard to Great Britain, only assumed a comparatively slight active participation, in view of the fact that England has her greatest interest centred upon the development of air traffic with the different parts of the Empire. It will, nevertheless, be necessary also for England, even if on a smaller scale, to participate in the European night air mail service, and to take over at least a part of the prospective night air mail service to the Continent. In my suggestion or scheme Germany has been allotted a larger share of the traffic, since, as we are aware, the latter country is touched by several lines, and the German Post Office furthermore has already displayed keen interest in the development of night air mail conveyance in Europe. To this might be added the circumstance that Germany, in virtue of her position in the centre of Europe, will be directly touched by several transit lines.

I would suggest that the traffic be arranged in the following way:—

The air line Berlin-Hanover-Cologne-Brussels-London is operated with two trips in each direction every night. Of course, there are no technical difficulties to prevent all the mail being carried with only one trip, but this is hardly feasible on account of the different demands made upon the time-tables, which will be put forward by each country. For as a *sine qua non* for a good night air mail time-table in Europe we must set up the following claims:—Departure at the earliest at 8 p.m. and arrival, if possible, for the first mail delivery next morning. If we therefore see how the line Berlin-Cologne-London should be operated, we shall find that with a cruising speed of 124 miles an hour the departure from one terminus can be put at 10 p.m., and delivery yet be made with the first round at the other terminus. If, however, a night mail aeroplane with mail from the Scandinavian countries is to connect with this Berlin machine to London on its landing at Hanover, the departure from the Scandinavian capitals must be made far too early in the afternoon, if the night air mail service were to be of any importance or benefit for business mail. The air mail 'plane would thus, at all events with the speeds which can now be attained, have to be dispatched as early as 5 p.m. from Stockholm, and this would be unsuitable. It will, therefore, be necessary, with a view to securing the connections from northern and eastern Europe to London, to duplicate the night air mail service between Berlin and London. *The first machine* with departure from Berlin at 10 p.m. might carry the mail from Berlin, pick up mail in western Germany and Belgium, and arrive in London at about 5 a.m. for distribution with the first delivery at 7.30 a.m. *The second machine*, on the other hand, would leave Berlin at midnight, carrying mail that has arrived from the Baltic States, Poland, Eastern Germany, and Czechoslovakia, and pick up at Hanover the mail from Scandinavia. The latter machine should arrive at Croydon by about 7 a.m. and the mail be delivered at 9.30 a.m. The mail delivered in London at 9.30 a.m. has left Stockholm on the previous night at about 8 p.m. and Copenhagen at midnight.

The first trip, which would mainly look after the interests of the German and Belgian Post Offices, would, it seems, have to be run by the Deutsche Luft Hansa and the Sabena jointly.

The second trip, on the other hand, will assume a more generally international character, and will look after the long distance traffic from Northern and Eastern Europe, and *vice versa*. I consider that this trip should be maintained in such

a way that the German Luft Hansa takes over the line Berlin-Hanover-Cologne, and the line Cologne-London is operated by Imperial Airways.

The connecting night air mail lines from north and east to Berlin and Hanover would, on the other hand, be operated by the airways companies of the respective countries. The Scandinavian Post Offices would thus, through the Scandinavian airways companies, operate the lines from the north, *i.e.*, from Helsingfors, Stockholm, Oslo, Gothenburg, and Copenhagen down to Hanover, where they would deliver and fetch the Scandinavian mail.

The branch line from Riga to Berlin should be operated by Deru-luft, the line from Warsaw to Berlin by the Polish Company, etc.

The line Cologne-Paris will become a Franco-German matter, while the night air mail line London-Paris-Marseilles might altogether be taken over by the French. Holland's connection from Amsterdam to London and Amsterdam to Hanover would entirely devolve upon the KLM.

Let us now try and investigate what economic prospects exist for organising the night air mail lines suggested here. The question is looked upon from different points of view in the different countries, *e.g.* Germany has adopted the system that the German Post Office pays the Deutsche Luft Hansa for the trips made instead of the transit income received from foreign Post Offices. The German Post Office thus charters the mail planes from the Deutsche Luft Hansa and pays a certain fee per kilometre.

Another method is that in use in the Scandinavian countries, viz. for the mail to be paid for according to the Hague Convention, 6 gold centimes per 100 grammes and 100 kilometres, with a certain guaranteed weight, which weight, however, pretty closely approaches the mail quantities actually carried.

The third method of arranging the economy of the night air mail services is to bring these flights under the other State aided flying, *e.g.* such as is the case with the Sabena's night air mail line between London and Brussels.

Whether the development of the night air mail service will be economically secured by the Post Offices chartering aeroplanes for the conveyance of mail, as in Germany, or by paying according to the Hague Convention, but with a certain guaranteed minimum weight (the method adopted by the Scandinavian countries), or by direct State subsidy, will have to be decided by the different countries. Whichever of these three schemes is adopted, the expenses for the respective countries will on the whole be the same for each kilometre flown, since in any case the bulk of the expenses for carrying on the flights must be defrayed from public money, inasmuch as the airways companies within the next few years will probably not be able to expect any income from passengers on the night air mail lines, and only some part of the operating expenses can be covered from income derived from freight.

Of the three different methods for economically securing the night air mail services I consider, however, the one adopted by the Scandinavian countries to be the best, since it is not merely the most businesslike but also the most advantageous from a public point of view; for by sending along all first class mail, the load-carrying capacity of the aeroplane is fully utilised, and the whole nation gets the benefit of the more rapid mail service.

The four Scandinavian Post Offices consider that as the holders of monopolies for mail conveyance they should not only benefit from such monopolies but also be obliged, out of consideration for the correspondents, to utilize every chance offered, and which is not economically insurmountable, for the purpose of bringing about an increasingly rapid mail service. For this reason the Swedish Post Office began several years ago to send along, by way of trials, with the ordinary day 'planes, which leave Malmoe in the morning after the arrival of the night mail train from the north, not only air mail but also 1st class mail *without an air mail fee*. After the Swedish Post Office had discovered that the regularity attained in daylight flights had been perfectly satisfactory, they increased from year to

year the conveyance of first class mail by aeroplane without an extra fee, so that the Swedish air lines now carry practically all such first class mail to European countries, which is, of course, delivered much earlier.

I would suggest that the method adopted by the Scandinavian countries for the economic performance of the night air mail service be generally adopted in Europe.

This night air mail conveyance of first class mail without air fee has also to a large extent been brought about in the conveyance of mail to Great Britain, but has there not been fully understood or appreciated. The four Scandinavian countries, as well as Germany, Belgium and Switzerland, which by making economical sacrifices, have improved the mail service to England, have discovered to their astonishment that this improvement was not looked upon with favour by the English Post Office, which in a memorandum addressed to the other Post Office Authorities commented unfavourably upon this gratuitous and rapid conveyance of mail to England. However, the Postmaster-General, although rather unwillingly, has now consented to take delivery of this aeroplane post although he seems to have omitted to take such measures for the conveyance of the mail bags to and from Croydon Aerodrome and the local post offices as are necessary for ensuring the full benefits of an aeroplane mail. Thus no fewer than three hours have been required for this local transport in London, or approximately as long as it has taken to fly from Amsterdam to Croydon.

At the Air Mail Conference held in Brussels last autumn a proposal was even submitted by some countries, including England, to the effect that the receiving Post Office might *forbid* the conveyance by aeroplane of any other mail but air mail. This proposal was not adopted, but the Conference granted to the despatching countries the right to forward first class mail by their air lines without air fee, when such is deemed suitable.

What difficulties exist then from a British point of view to adopt the same method as that which with advantage has already been tried by other countries, and which all and everyone will acknowledge to be the future means of conveyance for the mail?

If we look upon the question first of all from a postal technical point of view, it must be said that hardly any country in the world is in a more fortunate position than England. Practically all conveyance of mail to and from the Continent is concentrated upon a single spot, London, whereas the majority of the other countries have several points of issue. It will, therefore, be remarkably easy to despatch from Croydon, and receive there, all British Continental mail.

The economical side of the question, in so far as England is concerned, is not so very important.

According to a statement made recently by the Postmaster-General to a deputation from the British Chamber of Commerce, the British Post Office during the year 1929 had a surplus of nine million pounds. Yet only a fraction of this sum would enable the British Post Office to follow the example of the Continental Post Offices in respect to the conveyance of mail by aeroplane. Such a grant would still further consolidate England's position in the world of commerce.

I have tried, in the table reproduced here, to estimate the annual costs for the conveyance of all first class English mail by aeroplane to the European Continent. The estimates of weights have been based upon official international statements of the *number* of postal packets during the year 1928, and in assuming that these, as in the majority of countries, on an average weigh 10 grammes each, I therefore estimate that Great Britain has about 700,000 kilos. of first class mail per annum for the European Continent, and that, if *all* such mail were conveyed by aeroplane, both by night and by day, all the way, the annual expenditure would be approximately £166,000.

Destination.	Estimated weight in tons per annum.	Estimated average length of conveyance in miles.	Payment in £ per annum estimated according to the Hague Convention.
Finland	6	1,430	3,285
Sweden	20	930	7,135
Norway	16	1,060	6,470
Denmark	21	750	5,995
Russia	3	1,740	2,000
The Baltic States ...	6	1,240	2,855
Poland and Danzig ...	8	930	2,855
Czeckoslovakia ...	13	930	4,640
The Balkan States ...	23	1,800	15,865
Hungary	5	1,120	2,140
Austria	15	930	5,350
Germany	150	560	32,115
Italy	52	990	19,790
Switzerland	44	500	8,375
The Netherlands ...	71	310	8,445
Belgium	56	250	5,330
Spain	29	990	11,040
Portugal	12	990	4,570
France	150	310	17,840
Total number of tons	700	Total	£166,095

It should, however, be noted that the actual costs would be much lower, for firstly there cannot be any question of carrying by aeroplane any other mail than such as, by so doing, reaches its destination much earlier, and secondly the land and sea transit charges otherwise paid to the Post Offices of intermediate countries are saved, and thirdly there do not as yet exist from a time-table point of view suitable air lines throughout the year to all countries.

The bulk of the outward bound British mail could be carried by *British aeroplanes* to Cologne for transfer to other lines. A large portion of the British Post Office's expenses would thus be paid to an English company.

Before I pass on to the technical side of the question, I wish only to mention by way of comparison that during the year 1930 only 30 tons of mail were despatched by aeroplane from England to the European Continent, whereas during the summer months of 1930 no fewer than 65 tons were despatched from Sweden. It may also be of interest to note that $3\frac{1}{2}$ million postal packets were despatched from Switzerland in the course of last year, not even one-tenth of these having paid an air fee.

Fig. 8 shows the daily despatches in kilos. to and from Scandinavia by the different night air lines last summer. You will see from it that the night air mail *from* Scandinavia was remarkably large, whereas the mail *to* Scandinavia was trifling, and that on an average we sent 184 kilos. per trip to London, but did not receive a single kilo. *from* London.

The scheme for Inter-European Night Air Mail Traffic such as I have outlined, necessitates an investigation of the technical aspects into the possibilities of maintaining regular night-flying services.

Severe demands have obviously to be made upon the staffs both of mechanics and the aerodrome personnel, as well as upon the aeroplanes used. I shall now try and touch upon the main features of these problems, regardless of whether they have already been solved or still have to be solved, or are even now in the process of solution.

Owing to the immensity of my subject I regret that it is impossible to deal with it extensively this evening, nevertheless I would like to give you in the time at our disposal, some ideas about night-flying and which I have based upon American, Belgian, French, German and Swedish experiences.

Regular night-flying calls for tremendous physical and mental qualifications on the part of pilots. I am personally convinced that not more than 50 per cent. of the pilots at present engaged by the European Aero Services are suitable for this task. It must be from the younger men, who by virtue of their more up-to-date training are better qualified, that we are to obtain our recruits for this class of flying.

Estimated annual cost for conveyance by air mail of all English first class mail to the European Continent, with the application of the bases of payment adopted by the Hague Convention, 6 gold centimes per 100 grammes and 100 kilometres.

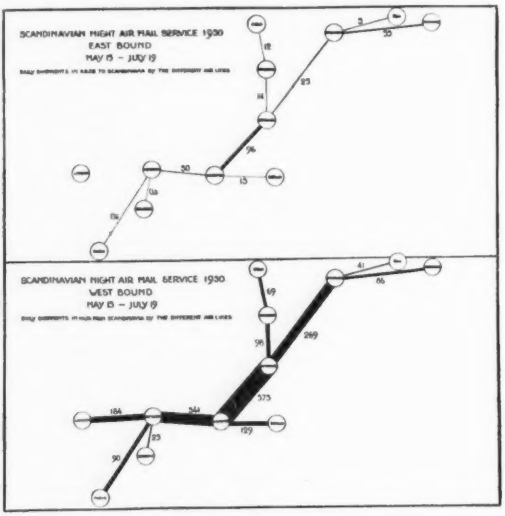
SCANDINAVIAN NIGHT AIR MAIL SERVICE 1930
EAST BOUND
MAY 15 – JULY 19
SCANDINAVIAN NIGHT AIR MAIL SERVICE 1930
WEST BOUND
MAY 15 – JULY 19

FIG. 8.

Unfortunately, when it is a case of "flying blindfold" our own sense of balance is absolutely useless to us. It even acts as a direct hindrance under certain conditions. Thus, as soon as the pilot loses his power of vision in the fog or darkness, he must be fully capable of navigating entirely by means of instruments, and furthermore be confident that he can do so without fear of making any error which might prove fatal. It is just this thought which frightens the still inexperienced pilot, who under certain circumstances can occasionally be subjected to great mental strain and worry. There is no middle-way between ordinary vision flight and flying "blind" or instrumentally. Many otherwise clever pilots have crashed with fatal results through imagining that there was.

We may say unhesitatingly, although with a certain amount of reservation, that reliable instruments are now available for the accurate navigation of aeroplanes flying "blind." Naturally the suitability of the individual types of machines must be taken into consideration in this connection. There must be a certain amount of inherent stability in an aeroplane to render the pilot's task easier and give him a chance of finishing the flight safely, especially during squally weather.

Instruments

A fundamental condition for "blind-flying" is an instrument which records the stability of the aeroplane round its horizontal and longitudinal axis and also its vertical axis of elevation. All modern instruments designed for this purpose are on the gyroscope principle and cardan pendular suspension. Gyro horizon indicators and turn and bank indicators are distinguished by different structural details, of which there are several combinations. Many of the different makes are very reliable but it would appear that the most suitable and preferable manner of propelling the gyroscope, which is so important for the proper operation of the instrument, is a detail to which utmost attention must be paid.

Pitot and venturi tubes are subject to perturbation as a result of water percolating into them or else as the result of ice forming in them. In the latest tubes there are electric heating devices. Other designs have an electric drive attached to the gyroscope.

In order to achieve an exact stability in the course of the flight, experiments are being made to find some device for making lateral steering possible, which device could be automatically operated or influenced by any deviations from the set compass course of an aeroplane. Trials made with new designs have proved promising.

It may be said that the following instruments are necessary for "blind-flying" equipment: A horizon indicator, a turn and bank indicator, a longitudinal inclinometer, a rate of climb indicator, air speed indicator, a compass and a reliable altimeter.

Even supposing that reliable instruments are available so that starting and perfectly safe flying in fog and darkness may be undertaken, safe landing without being able to see the ground is as yet, however, practically impossible. An altimeter which shows the exact height at which a machine is flying above the ground, does not exist. Altimeters based upon barometric pressure of the atmosphere are not, even with their extremely sensitive devices for correction and adjustment, so accurate that they can be considered as reliable instruments when landing. The "echolot" used extensively for maritime navigation seems to encounter certain difficulties in aeroplanes. On the other hand, the trials proceeding in America with a radiolot have been more successful and appear to promise good results. Another factor of uncertainty, which apart from the determination of altitude, adds to the difficulty of making a "blind" landing, is the difficulty of determining the exact position and size of the aerodrome. Even here we might be able to rely upon wireless to get a satisfactory result. The pilot could, either through picking up verbal signals with his headphones or visually with the aid of some instrument, glide down towards the end of the aerodrome in a kind of "tunnel" through space, which could be both horizontally and vertically outlined to him by means of wireless messages.

In this connection it should be noted that the aeroplane ought to be equipped with a fixed wireless antenna which can be used when visibility is poor, as the machine approaches the aerodrome, as a help in landing. By this means the wireless can be used right up to the moment when the landing is made.

As will be seen from the foregoing, there are numerous difficulties still to be overcome before "blind" landing can be made safe, in conjunction with the now possible "blind" starting and flying. As soon as this is achieved scarcely any atmospheric conditions can any longer act deterrently upon air traffic.

Lighting Arrangements for Night Landing

In order to enable safe landing at night the aerodromes must be equipped with complete illumination for night landing. The demand for the necessary volume of light, minimum expenses for operation and upkeep, as well as the

utmost possible reliability means that only an electrical plant can be taken into consideration for this purpose. The main parts necessary for such a light installation are:—

Aerodrome Lighthouse.—With a light of such a distinctive character as to enable the aerodrome to be identified. For this purpose the most suitable aid is a powerful electrical intermittent flash light or rotating beacon. The lamps should be about 1000 watts.

Obstruction Lights.—These are erected on all obstacles existing in the vicinity of the aerodrome, as well as on hangars, wireless masts, etc. These beacons should show a red light either fixed or intermittent. Strength of lamps about 300 watts.

Boundary Lights.—To be placed along the borders of the aerodrome at intervals of 300 to 500 feet from one another. These beacons should show a light whose colour differs from that of the obstruction lights. Sweden has adopted a chrome-yellow tint. Strength of lamps about 200 watts.

Wind Indicator, with illuminations, is set up at some suitable clear spot close to the aerodrome, where it cannot be affected by local interferences in the direction of the wind.

Landing Flood Lights.—For illuminating the surface of the aerodrome on landing. For a large aerodrome of about 1,000 yards diameter 6 flood lights of at least 10 kw., uniformly placed round the aerodrome, will be required. When in use two aggregates are always lighted with one unlighted aggregate between them, by which means consequently the pilot on landing or starting gets the light obliquely from behind on both sides. By this means all dark shadows on the aerodrome and also part of the risk of dazzle, which is greatest with illumination from one point only, are obviated. The source of light, which according to local conditions should have a horizontal spread of 90° to 150°, and may either be collected in a joint lens or distributed amongst several searchlights, should have a focal height of at least 3 metres above the ground, not only for being able to get sufficient vertical illumination of the ground but also to enable efficient screening of the light upwards, so that it cannot interfere with the pilot on making his landing. The vertical spread of the flood-light should not exceed 3°. The great power of light is absolutely necessary in order that the flood-light under critical circumstances with poor visibility may be capable of being moved to serve its purpose.

Front Illumination of hangars or other large free-standing objects, so that their figure of space is distinctly marked. This is necessary in order to enable the pilot before landing to get an opportunity to control and adjust his eyes, for after a prolonged stay in darkness there is a tendency of losing stereoscopic vision and in doing so also the capacity to judge distance.

In Sweden there is at present being erected a night landing illumination plant at the Malmoe aerodrome, Bulltofta, on the lines I have mentioned here.

For navigation along the night air routes between the different aerodromes the pilot must not only have available wireless connections, to which I shall revert later on, but also light beacons. Opinions differ very much in respect of the most suitable organisation of a night air route. In certain circles beacons are considered unnecessary, in others necessary, and it is only with regard to the use of wireless that opinions coincide.

Beacon Air Routes.—A more thorough study of all the factors determinative for regular traffic goes, however, to prove that beacons must be looked upon as necessary, and also a system of emergency landing places. Blind flying is certainly now possible, but making a blind landing is as yet unsolved; blind flying under all conditions calls for experience and routine which tell us that we should not, *à priori,* look upon it as the normal method of navigation; reliability of the navigation instruments and the aeroplane engines are great and grow better and better, but hardly reach one hundred per cent.; moreover the night air

routes shall not only be practicable for the trained traffic pilot but also for all other civilian flying activity, etc.

The strain in blind flying is still so great that the regular night pilot needs those opportunities for control of his instruments which can be afforded to him by beacons or other landmarks on the ground with clear vision. He has on these occasions a chance of strengthening his trust in his instrumental equipment on board his aeroplane, which can only fortify his moral power and endurance for worse weather conditions, and not *vice versa*, as has been advocated from several quarters. A real night pilot knows that, as I have previously pointed out, there is nothing intermediate between flying by sight and flying by chance, but either one or the other. Likewise that difficulties encountered after having started on a flight can hardly be avoided by turning, but that the completion of the flight depends upon his conscious trust in the instruments he has on board.

We may assume that the occasions when the pilot on account of stormy, squally weather is forced to make an absolute blind or chance flight are just as many as when blind flight becomes necessary by reason of deficient vision. Blind flying in squally weather causes a far greater strain than flying in a fog, and has also with absolute certainty its limit in the event of no beaconed route or the like being able to give the pilot a chance to unbroken control of his navigation. Blind flying is a form of navigation which with all certainty can, and shall, be carried out when such becomes necessary for purposes of regularity, but it shall not form the foundation of the safety organisation which a beaconed route is in need of for regular traffic.

The main principles for the establishment of a night air route, I consider, must be: as *straight* a route as possible between the respective aerodromes; emergency landing places not more than fifty miles apart; beacons not more than fifteen to twenty miles apart; wireless organisation which enables safe connection with the pilot, no matter where he may be along the route; wireless direction finding in the shape of taking the direction of the position or course from the ground stations as well as wireless beacons, where such is found necessary; and meteorological service organised in view of the general meteorological conditions along the air route.

Intermediate Landing Grounds

The intermediate landing grounds, which should be located close to the air route and have the most favourable location possible for entering them, should extend to something like 600 metres in the directions of the wind mainly prevailing. As regards night illumination, they might be provided with landing beacons, obstacle beacons, border lights, wind indicator, and cloud altmeter. As a matter of principle there should be stationed a meteorological observer at every emergency landing place. As a general rule it holds good that in the establishment of aerodromes they should be placed as high and open as possible, and that no place in a depressed position should be chosen.

Beacons: Their Design, Construction and Location

As beacons along air routes the rotary, electrical types have proved their usefulness and suitability. Gas beacons do not give off a sufficiently powerful light, and are also much more expensive in operation and upkeep, for which reason they should only be made use of in such places where an electrical plant is out of the question economically. The location of beacons as a matter of course depends upon local conditions, but the source of light should be so high above the ground that it affords absolutely safe marking of a free flying altitude in its immediate vicinity. In mountainous districts through which the air routes pass, it is important that the beacons should be located at the highest points in the lowest lying ground where it is possible to establish the air route. Of

course, it is necessary in undulating terrain and where the air route is passing through valleys, to restrict the distance between the beacons, so that the latter are perfectly visible from one another. Changes of course in the air route must be marked by a beacon with a perfectly unequivocal character of light for its identification, and changes of route should, as far as ever possible, always be located in direct conjunction with an emergency landing place.

The requisite light power in the white clusters of rays in the beacon can be made dependent upon local conditions at the place where the same is erected, yet at least 1 mill. and at the outside 2 mill. Haeffner lights must be looked upon as necessary, emanating from a distance of 15 miles between beacons. The horizontal spread of the clusters of rays is partly dependent upon the character of light intended for the beacon. The vertical spread amounts as a rule to $4-6°$ with an elevation of about 2°. The size of lamp is mostly 1000 to 1500 watt, depending upon the structure and design of the beacons. The periodicity in the intermittent character of the beacon must not exceed 10 seconds. The character of light of the beacons is produced either solely through the source of light or by other sources of light connected up synchronously with the former, thus no dark part in the period of the direction of the air route should exceed 3 seconds. In order to give a light impression fully comprehensible for the human eye, no part of the light in the period must fall below 1/10th of a second.

In order to enable safe identification of a beacon in view of the possibilities of confusion with other sources of light in its vicinity, or for the purpose of indicating a near-by emergency landing place or change in the direction of the course, etc., coloured lights may be used. Those colours which in this respect have proved to possess the best and greatest signalling effect, are chrome-yellow, red and bluish-green. In virtue of their considerable absorption of light the coloured lights should, however, only be used to such an extent as is absolutely necessary. As warning beacons against obstacles projecting in the terrain, the Neon-light has proved very efficient.

The demands of one to two million Haeffner candle-power in the beacons, as stated by me, are based upon the very latest experiences made in this matter both in America and Germany. The first German night air routes were established on much smaller pretensions as to candle power and distance between beacons, but experience has taught us now that the American idea, which almost from the start adopted powerful beacons at comparatively short distance from each other, was the right one.

Atmospheric absorption of light is, unfortunately, such that a directly practicable relation between candle power and distance between beacons can hardly be set up for the practical conditions. We do not attain any material increase in the scope of a beacon by a continuous large increase in the candle power. Nevertheless, the latter should be adapted in such a way that the beacon close to the degree of invisibility in the atmosphere, which in any case forces the pilot to pass over to blind flying, possesses an absolutely safe signalling efficiency for the pilot, *i.e.*, within a radius of at the very least the distance forming the limit value for that daylight vision under which flying with ground orientation should be carried out, viz., about one mile. When flying at an altitude of 1000 to 1500 feet, and with a distance of about 15 miles between beacons, the pilot in orienting himself from beacon to beacon has in these circumstances always, in steering for the next beacon, a sector of approximately at least 8° available for the purpose of getting within the radius of the signalling effect of the beacon for which he is steering.

Crew

The pilot's need of having available for his navigation during the night, meteorological reports, directions, etc., is of such importance that it seems to me

absolutely imperative that the crew on board a night mail aeroplane consists of at least two, the pilot and a wireless operator. The wireless operator can preferably be a pilot with a telegraphist's certificate.

Wireless

Already existing and planned wireless stations for air traffic in Central Europe are, maybe, undoubtedly competent to supply information as to position and course for the anticipated night air mail lines. Wireless beacons might to advantage be made use of, particularly along air routes difficult to navigate in mountainous regions, etc., and also for air routes and aerodromes with such a vast amount of traffic that the ground wireless stations concerned are unable to manage the necessary work.

On the larger aeroplanes there may also be fitted with advantage direction finders, by which one will be enabled to determine one's position on board. The wireless beacons erected along the American night air mail routes seem to have a signalling radius of something like 100 to 150 miles.

Meteorological Service

The demands made upon rapid and concise operation of the meteorological services for flying will become keener for the purposes of flying at night. As long as the blind-landing problem remains unsolved, there will be a need at critical moments, *e.g.*, when fog is seen to block the air routes, of continuous, rapid and reliable reports about vision, and a knowledge of wind and cloud altitude conditions at all landing places concerned along the air route. It seems to me therefore advisable to consider whether the extremely efficient American system of reporting with automatic telegraph-typewriters should not also be introduced along the bigger night air mail lines in Europe. Every meteorological point of observation should be provided with instruments for measuring the altitude of the clouds and visibility in darkness.

Aeroplanes

I shall now come to, perhaps, the most important factor in the problem of a reliable and economic night air mail service, the most suitable type of machine.

As I have just pointed out, the speed with which mail can be carried is the whole importance of a flying post. Consequently, a claim to speed will be the most insistent demand made upon the right type of aeroplane. A review of the various transport times on the most important long distance night air mail routes in Europe shows that a cruising speed of between 125 and 140 miles must be reached. Furthermore, a mail-carrying aeroplane must have a good load-carrying capacity and a sufficient range.

The load-carrying capacity of the aeroplane for mail becomes naturally different for the different lines, but we may assume that it varies between 1,000 and 3,000 lbs. The demand for range not only depends upon the length of the route to be covered, but also upon general meteorological conditions along the scheduled route, frequency of fogs, etc. While for Swedish conditions we may consider a fuel reserve of 50 per cent. sufficient, the Sabena for its night air mail line between Brussels and London at the present time lays down a fuel reserve of 200 per cent. for the purpose of enabling the pilot— in the event of a particularly troublesome fog on the line Brussels-London shutting off the available landing places—to have a sufficient fuel supply to enable him to continue his flight either until such time as the landing conditions improve or for reaching some more distant station free from fog. When the problem of landing in fog has been solved, such a safety measure will naturally become unnecessary.

To give the performances which are thus required of the night air mail planes it is obvious that several classes of size must be taken into consideration. In doing so we get to the safety view point in so far as concerns the installation of the engine. Single engine or triple engine, that is the question. The demand for high speed speaks in favour of the single-engine installation; safety, on the other hand, points to a triple-engined one. No definite attitude towards this question can be reached unless it is discussed directly in conjunction with the general conditions and circumstances, both relating to weather, terrain and ground organisation, which exists along the air route on which the aeroplane is meant to be employed. A triple-engined aeroplane of to-day with a cruising speed of 110 to 115 miles does not satisfy the demands of night air mail service for speed. For the Scandinavian night air mail service, *i.e.*, on the lines Stockholm-Copenhagen and Oslo-Copenhagen, as well as Copenhagen-Hanover, the following two specially designed types of aeroplanes with a cruising speed of 135 to 140 miles per hour and 50 per cent. fuel reserve, appear to me suitable:—Single-engined, about 600 h.p.; load capacity, mail 1,000 lbs.; triple-engined, about 1,800 h.p.; load capacity, mail 2,500 lbs.

The large type would also permit the carrying of one or two postal officials for sorting the mail on the way.

In addition to the requirements already mentioned, a cruising speed of 135-140 miles and a loading capacity of 1,000 to 2,500lbs., my company has fixed the following important conditions for the air mail planes suitable for the Scandinavian lines:—

1. Landing speed, 68 miles/hour.
2. Rate of climb at sea level, 800 ft./min.
3. Range at cruising speed, 4½ hours or about 600 miles, corresponding to the longest non-stop flight on the route with a reserve of 75 per cent.
4. Capacity of mail compartments at least respectively 150 and 500 cub./ft.
5. To protect the crew in the event of a forced landing, the seats in the one-engined plane must be arranged behind and above the mail compartment.

The demand for very great inherent stability in a night air mail 'plane cannot be sufficiently emphasised. It must, so to speak, be positive and not merely of the more apparent nature, as is still the case with so many types of aeroplanes.

Glaciation: The Forming of Ice on Wings and Propellers

Another very serious problem which has become manifest in conjunction with an extension of air traffic even to the dark part of the twenty-four hours, and throughout the year, is the *risk of glaciation* or coating of ice. The utmost efforts must be made to find a remedy against the unavoidable glaciation of wings and propeller, which takes place when passing through air saturated with moisture or fog with the temperature at about freezing point. It has so far not been fully elucidated as to what imminent perils an aeroplane is exposed when becoming coated with ice, for it may become unmanageable or unsteerable in a few minutes on account of deformation of the wings and the overload on the aeroplane consequent upon the coating of ice. It is not always possible to succeed in evading this danger by seeking air strata with pronounced higher or lower temperature. The suggestion has been put forward to prevent the ice from getting a hold by fixing electrically heated metal wires zigzag on their front edges. The problem is remarkably important, because in this glaciation I see a very great bar to all really regular air traffic in winter.

Discussion

Mr. M. L. Bramson: He had had the good fortune to be closely associated with Captain Florman six or seven years ago when the latter was working on the problem, which he solved, of forming the first Swedish air line, and he could assure them, not only from personal observation then, but from subsequent facts, some of which they had heard that night, that it was by no means an accident that Captain Florman found himself at the head of the organisation which had a monopoly of air lines in Sweden. Captain Florman was a perfect genius at pulling the right strings, and getting Governments to do what he wished. Mr. Bramson had been told that day of a further proof of this. On the day of his arrival in this country the Swedish Parliament for the second time granted a subsidy to Captain Florman's line of, he thought, 750,000 Swedish crowns per annum for six years, which was an increase over the amount originally granted. One feature of that subsidy was worthy of special attention. Part of it was earmarked for blind flying experiments. That was an admirable innovation which he thought was unique in Europe. The Government in this country might be spending some money on blind flying equipment at the Government experimental station, but the equivalent to Sweden's action would be the granting of a subsidy to Imperial Airways for the purpose of making experiments in night flying under air line conditions. Captain Florman was to be congratulated upon getting a very practical form of subsidy out of his Government. He wished that one could do as much here.

Baron Legatinere (of Aeropostale Air Transport): Captain Florman had done remarkable work. His (Baron Legatinere's) line had been running for nearly three years a daily service to Morocco and a weekly service to South America, and that week they had completed the 325th journey both ways, with the loss of only two mails. They had not been doing all the journeys in that time, but during November and December last each journey was done in seven or eight days. From Toulouse to Casablanca, the first section, was 3,000 miles; from Dakar to Natal, the sea section, which was now covered by boats, was 2,000 miles, while the section on the South American side was also 3,000 miles. That was 6,000 miles of land and 2,000 miles of sea. The sea section occupied four to five days, according to weather, which left only three or four days to fly 6,000 miles. Naturally to do that they had to fly the whole time. A plane left Toulouse at six o'clock every Sunday morning. Its first change of plane was at Casablanca, and it arrived on Monday after lunch at Dakar. Those 3,000 miles had been flown in a day and a half. On the other side the same thing applied. On the way back the mail left on Friday night just after 12—really Saturday morning—so they had to start back at night, and on the return journey, depending on the weather, they might be overtaken by night at any point, so the whole line had to be equipped for night flying. Every landing ground was installed with a lighthouse of 3,000 watts power, on top of which was a small light giving the letter of indication of the aerodrome, etc. In some places, not everywhere, they had intermediate lights. Every ground was illuminated by flood lights. Every plane, as well as every landing ground, was equipped with a complete wireless set, short and long wave direction finders, the same as for ships. Pilots were required to fly sometimes during the day, sometimes during the night, therefore every pilot had to be trained to fly at night, and as far as he knew they had never had any accident due to night flying. Their accidents were due to heavy fog and sandstorms. Probably they knew that night-flying along the Mauretanian coast and the coast of South America was very difficult—thunderstorms and fog were encountered. His organisation had on every ground a meteorological installation. Each pilot, before leaving, was told what weather he might find and at what height he had a chance to get the best wind. They had found that for the time being the best planes were single-engined mono-

planes, Latacoere mark 25/28. They were fitted with 450 and 600 h.p. engines, Renault or Hispano. The speeds of those planes were 130 to 150 m.p.h. and their range from 600 to 900 miles. Between Toulouse and Dakar there were twelve stops, with several changes of plane. On the other side also there were several changes of plane. That meant a quick flight to take over the mailbags. Sometimes there were over 150 bags, so there was no time to lose.

Mr. HANDLEY PAGE: When one saw particulars of the total loads carried to different parts of Europe one realised the limited extent to which on the existing state of affairs the air could be used for the conveyance of correspondence. Captain Florman estimated the total cost at £160,000. On the supposition that the whole of the correspondence were carried by air, it would be interesting to know what it would cost the transport companies who carried on the service on the lines indicated by Captain Florman, as compared with their receipts. One thing stood out in his paper very prominently—the attitude of our Post Office. It was said that the spectator saw most of the game. He was sure that Captain Florman, looking on, had seen a good deal of the game—if one were right in describing the operations of any British Government department as a game. But it certainly seemed extraordinary that here in a country which was supposed to be very hard up and on the edge of bankruptcy they paid out nearly half a million a year freely in subsidy, yet the Government did not insist that any mail should be carried in return, but only that so many hundred or thousand miles were flown. He would have thought that if the Government paid out a large sum of money in order that air transportation should continue they would have liked to have a letter or two carried for nothing, but they did not insist on that. The Post Office said that it was a matter for the Air Ministry, and if they—the P.O.—approved the air service, and there was no great danger, and the regularity was good, then they would be pleased to pay the price for the air mail to be carried. Looking at that picture of the Scandinavian air mail, and the amount that came from London, he wondered if the Post Office was adopting the modern cry that this country should have protection, because their policy, he thought, completely stopped letters going out of this country by air mail, presumably on the theory that they should no longer correspond with people who were desirous of sending foreign goods to this country. He was sorry that Captain Florman had not read the whole of his paper, because he had some rather spicy remarks in it, particularly where he said, referring to the service from Scandinavia, that the English Post Office in a memorandum addressed to the other Post Office authorities, even requested that this gratuitous and rapid conveyance of mails to England should stop. He would like to inquire of Captain Florman—though not doubting his word for a moment—whether that was really true; if so, they ought to have printed with chapter and verse in Captain Florman's reply the exact statement that was made. It seemed incredible that such a thing could be said, but he must say that he did not doubt it. He thought the Post Office was quite capable of it. He did not know whether Captain Florman had considered whether portions of the London-India route could be advantageously planned for night flying. It would be interesting to know what sections he would recommend as opening up possibilities for night flying on that route.

Mr. GORDON ENGLAND: He disagreed with Mr. Handley Page's remark that they should congratulate themselves and thank Captain Florman for his paper. It was very depressing that he should come and read such an admirable paper in this country, because he had exposed them to an attack from the British Post Office. In this country any reasonable proposal was quite certain to be turned down by the "competent" authority; the only things which officials were interested in were wild and entirely uneconomic schemes. Therefore he was afraid that Captain Florman had done them a disservice in his attempt to perform a friendly act. That point had been amplified by Mr. Handley Page. He hoped, however, that that very worthy paper, *The Times*, which was at present

giving the country such excellent doses of Andre Siegfried, would be able to effect a change in the attitude of our Government officials. Surely the speed of 140 miles per hour mentioned by Captain Florman was nothing like sufficient; the speed of air mail machines should be much nearer 200 miles per hour. Would Captain Florman agree that as the result of investigations in America it had been found that any machine with a speed of less than 200 miles per hour was of no real use for air mail work? If that were the experience to-day, he suggested that manufacturers, when they received encouragement at long last from the Post Office, shou'd turn their attention to making machines capable of at least 200 miles an hour. Further, he would like to ask Captain Florman if he agreed that machines with only a pilot on them were not likely to have very much future in this particular service; that machines must be of such a size that the saving that would be effected by the dropping of an extra pilot, radio operator, or mail sorter, would be inadvisable. Was there any reason why, under the regulations, the service should not be extended to carry high class parcel post matter? There was a great opportunity there for considerable development, that would enable a minimum economic service to be conducted on those routes where the actual letter mail would be far too light. It seemed to Mr. Gordon England that the type of machine was of utmost importance. He suggested that the machine could not be an adaptation of either a passenger-carrying machine or a night bomber, or something of that kind, that an entirely separate type was wanted, and that if there was going to be some international development of night flying, the aerodromes selected for this particular operation should be of first class nature. Consequently machines of very high speed—and perhaps very high landing speed—would be practicable, and they should be fitted with retractable undercarriages, in order that there might be some hope of attaining a speed of 200 miles per hour with reasonable expenditure of power, which was now considered in America to be the absolute minimum.

Lieutenant VAN DEN EYDNE: In his opinion the beacons on this side of the Channel were not sufficient. He had been flying for about a year between Brussels and London and he did not know why more lights were not placed between Dover and Croydon. The only ones on their route were those at Croydon, Tatsfield and Dover. They had been flying for about a year, and were very satisfied with the route and with the radio. The only thing they would like improved was the illumination of the landing ground at Lympne. There were only small lights on the ground, and Lympne was a very dangerous aerodrome for night landing. It was situated on a hill. A machine experienced great difficulty in landing in foggy weather, which was frequently necessary when Croydon was closed.

Major MEALING (Air Ministry): Captain Florman had detailed the lights and the ground organisation generally that were needed for a regular night service, but he had not mentioned that important point of the cost of that ground organisation. They had worked out the cost of a complete night organisation between Lympne and Croydon. Incidentally, he was glad to say a flood light would be installed at Lympne within a month or two. The cost was well in excess of £1,000 per mile for the ground organisation. He would like to hear what the lecturer had to say about that.

Major GREEN: The lecturer had suggested that an aeroplane with a single engine was necessarily faster than one with several engines. While admitting that at the moment single-engined machines generally were faster, there was no particular reason why they should be so. It is an obvious advantage to be able to fly with one engine stopped, and so long as the multi-engined machines fulfilled this condition they were likely to be more profitable and more useful for mail carrying than Captain Florman suggested.

Major Green had discussed blind flying with many professional civil pilots. While it was true that none of these pilots would admit that he did not know all

about blind flying, each one was quite certain that there were a great many other civil pilots who could not manage blind flying at all. He therefore thought there was something lacking in the training of civil pilots and that many of them did not really understand what blind flying was and that the sooner this was put right the better it would be for civil aviation.

Captain WILCOCKSON: To him the most interesting part of the discussion was the training of the pilots in blind flying. It was going to be very difficult, because, in his opinion, the pilot had to spend hundreds of hours in the air before he was capable of blind flying, and the development should be more on the lines of a really efficient instrument for taking the pilot's place, so that blind flying could be done entirely with the instrument instead of by the pilot. It imposed too much strain on a pilot to go on hour after hour blind flying entirely on his own responsibility. If he had an instrument to relieve him he would only have to sit there, and Mr. Wilcockson thought that that would be the ultimate solution of the problem of blind flying.

Mr. L. A. WINGFIELD: He was interested in Captain Florman's statement of the necessity for young pilots for night flying. That was contrary to all experience with regard to day flying. It would be very useful at a later stage to have information in writing as to the method adopted for training pilots.

Colonel THE MASTER OF SEMPILL: He had followed the paper with great interest. He felt sure everyone would agree that the paper dealt with the most important aspect of air transport, namely, the carriage of mails on a 24-hour schedule.

Everyone would be struck by the unsympathetic attitude apparently adopted by the British Postal Authorities. He had no knowledge of the particular statement regarding the British Post Office made in the paper, but as he was intimately concerned with the Civil Aviation Section of the London Chamber of Commerce, he did know that that body had been experiencing difficulties in convincing the Postmaster-General as to the necessity of encouraging the development of air mails. The London Chamber of Commerce had met with objections raised by the Postmaster-General of an utterly insignificant and, it would not perhaps be too much to say, frivolous character, in regard to air mail developments and in regard to the introduction of a lower minimum weight, viz., ½oz. One of the objections seriously put forward by the authorities to the introduction of the ½oz. minimum weight was the financial burden that would be involved in issuing ½oz. weights to the post offices in the British Isles.

The London Chamber of Commerce was pressing for the inauguration of experimental night air mail services to important European capitals, but the most important aspect was the provision of night flying facilities and special air mail machines on the Indian and African air routes. The Chamber had had a very happy meeting with the Air Minister and other high officers of the Air Ministry, including the Director of Civil Aviation, and it had been found that the Ministry were extremely sympathetic and stated that everything should be done to bring about a fuller development of the air mail.

On a recent short seaplane tour in Scandinavia and the Baltic States, he (the Master of Sempill) had been very much impressed with the excellent facilities provided at the principal towns, and it seemed that all such facilities had been provided, and were controlled, by that powerful company of which Captain Florman was the moving spirit.

The CHAIRMAN: Before asking Captain Florman to reply to the discussion he ought to mention that the Society had received a letter from the Postmaster-General on the points which had been touched upon by Mr. Handley Page and Colonel Sempill in regard to the statement that the Post Office wanted the air mail stopped. The Postmaster-General denied the statement. He had not time then to read the letter, but it would be published in full in the Proceedings. The Post Office did inform other Post Offices, however, that they were of opinion that

the time had not yet arrived when the ordinary mail could be sent by air. The Chairman thought that Captain Florman had sufficient ground for the impression that he had obtained, and that most of those present would support the views expressed by Captain Florman and others as to the attitude of the aviation community towards the Post Office.

Mr. FRANK RADCLIFFE (*communicated*): Captain Florman's information regarding the experimental night service carried out by the Aerotransport Company between Stockholm and London during the past two years should act as a spur to the British Postal Authorities to consider seriously the claims which air mail services make. At the same time it should be remembered that Scandinavia occupies a unique position which makes the operation of air mails of the utmost importance. The alternative to air transport is a combination of land and water transport, with its inevitable delays, and, in the case of the Scandinavian countries, the delays can be aggravated by the severe winter conditions. The same conditions do not apply to the same extent here, and the attractiveness of air mail generally is not so evident, due to our existing means of transport being naturally capable of higher efficiency. Thus, unless an air mail service can be organised which offers material advantages over the present services there is not the incentive present for its introduction. The advantages comprise punctuality, reliability and acceleration of service.

The London Chamber of Commerce has advocated for some time now the introduction of fast mail carriers cruising at 150 m.p.h. carrying 1,000lbs. of mails for 1,000 miles. With such aircraft developed then the aeroplane can offer to the G.P.O. a real alternative, but it must not be forgotten that such aircraft do not exist anywhere in the world to-day, and as there will be, naturally, a reasonable time necessary for experimenting before such a service can be guaranteed, the case put forward by the P.M.G. does not appear so short-sighted after all.

It seems to the writer that the sooner the aircraft industry can demonstrate by actual examples what can be done the sooner will air mails become realities for this country.

Developments have been going on for some time now in many parts of the world and if use is made of all this research, the results co-ordinated and embodied in new designs, progress should be rapid and the case for the mail plane made.

It may be pointed out that a discussion of mail planes is somewhat irrelevant, but to the writer it seems imperative that the actual type of aircraft should be placed foremost in the discussion.

Captain Florman's remarks regarding the necessary fuel reserve for assuring the pilot every possible chance of flying out of a fog region is of very great importance and one which is apt to be disregarded. Its provision robs the mail plane of a big percentage of its pay load, and with the high speed demanded the utilisation of Diesel-engined craft seems imperative if economies in the non-paying portion of the disposable load are to be made.

It seemed to the writer that it might be of interest if the table given showing weight of first class mail from London to Europe were investigated a little more fully.

For this purpose the following table is given which gives the average daily weight of mail to the various countries and for practical reasons the table has been arranged so that convenient areas could then be served by a single service. Even so it will be seen that the volume of mails carried would not justify a British service being contemplated except perhaps in the case of Groups 3 and 4. It would appear from this analysis that international co-operation alone is the ultimate solution to practical European air mail services, and that the sooner this can be achieved the sooner will a practicable air mail service be possible.

ENGLISH AIR MAILS TO EUROPE.

	Destination.	Estd. wt. in lbs./day (6 days per week).	
1.	Finland	43	= 574 lbs./day.
	Sweden	144	
	Norway	115	
	Denmark	151	
	Russia	21	
	The Baltic States	43	
	Poland and Danzig	57	
2.	Czechoslovakia	93	= 402 lbs./day.
	Balkans	165	
	Hungary	36	
	Austria	108	
3.	Germany	1080	= 1,992 lbs./day.
	The Netherlands	510	
	Belgium	402	
4.	Italy	374	= 1,770 lbs./day.
	Switzerland	316	
	France	1080	

The Empire air mail lines seem to demand special consideration by the countries concerned and for the time being, until aircraft are available, the present scheme of using the existing services run by Imperial Airways seems the only satisfactory one.

The information obtained by Imperial Airways should prove invaluable for building up the permanent schemes of the next decade.

REPLY TO DISCUSSION

Replying to Mr. Handley Page, it was very difficult to estimate the cost of night air mail traffic; it depended on the machines; but they had found in Sweden that the payments under the Hague Convention were sufficient for his company. Mr. Handley Page had asked a question with regard to the statement appearing in the unrevised copy of his paper that the British Post Office had asked them to stop the air mail service to England. In the paper he had read he changed the wording a little and said that this improvement was not viewed with favour by the English Post Office, which, in a memorandum addressed to the other Post Office Authorities, commented unfavourably upon the gratuitous and rapid mail to England.

He was sorry that he did not know enough about the India route to give any advice as to what could be done in the way of night flying. He thoroughly agreed with Mr. Gordon England that a cruising speed of 200 miles would be ideal, but in his paper he did not dare to ask for such a speed. They would be satisfied with 200 kilometres, or 124 miles, per hour for the next year.

Parcels were good freight for aeroplanes, of course; on the other hand, according to the Hague Convention, parcels were paid for only at the rate of two gold francs per kilogramme per 1,000 kilometres flown, as against six gold francs for letters. Therefore during the next two or three years they did not press for parcels.

Major Mealing had inquired the cost of organising the lighting of air routes. It was very high indeed. His reply to Major Mealing was the same as his reply to the Swedish Parliament: A complete system of lighting between Stockholm and Malmoe would cost 400,000 crowns for the illumination only, but even so the Swedish Government were constructing a railway in Lapland in the north

of Sweden, where the population was very small, at a cost of about 400,000 crowns per mile, a sum equivalent to the cost of lighting and marking for night flying the whole of the air line route between Stockholm and Malmoe.

That Scandinavia occupies a unique position which makes the operation of air mails of the utmost importance holds good not only for Scandinavian mail *to* England, but, as a matter of course, in the same degree for mail *from* England to Scandinavia.

The alternative to air transport is not a combination of land and water transport, for according to the Swedish proposal only land machines are required. There are no difficulties on account of winter conditions. The dividing up of the line for ski or wheel base, as the case may be, is only altered so as to adapt the machine to the requirements of the different seasons. The only difficulties encountered are caused by *fog*, and these difficulties are just as great, if not greater, in England.

Punctuality, reliability and acceleration of service are attained more easily on one properly managed, paying line than on many split-up ones. As regards the aeroplanes, the Postmaster-General's view of the matter is perhaps not so short-sighted, but all clear-sighted persons should in plenty of time direct their attention to the aim and object: A simple, cheap, efficient network. The time table for such a prospective network should gradually be improved in the same measures as technique achieves fresh improvements. It is not advisable to establish other lines during the experimental years, as these may not be capable of future economical maintenance. Past experiences can then not be fully utilised.

Of course, the employment of Diesel-engined craft seems imperative for the moment, if economies in the unprofitable portion of the pay load are to be effected. But a prospective project should not be directed towards immediate, palpable profit, but rather towards the great gain in time and economy by not jumping restlessly from one proposal to another, but a plan should be drawn up beforehand, which will curtail and cut down the minor claims from various interested countries, but to the utmost extent will satisfy *all and everyone* in the cheapest and best possible manner.

Regarding Mr. Radcliffe's table, English Air Mails to Europe, the Swedish project solves all the problems, but it assumes that the *weights* are multiplied, by the gain in time achieved. In Mr. Radcliffe's interesting summary should there not have been deducted mail which does not achieve any saving of time whatsoever by air transport, and the weight has not been graduated in proportion to the saving of time.

GENERAL POST OFFICE, LONDON, E.C.1,
4th March, 1931.

Sir,—I am directed by the Postmaster-General to acknowledge with thanks the receipt of your letter of the 26th February in which you were good enough to invite him to a lecture to be delivered by Captain Carl Florman on the 12th instant.

The Postmaster-General observes that in the third paragraph of your letter it is stated that according to Captain Florman the four Scandinavian countries, Germany, Belgium and Switzerland " discovered to their astonishment that the improvement of the air mail service to England was not looked upon with favour by the English Post Office, which in a memorandum addressed to other Post Office authorities even requested that this gratuitous and rapid conveyance of mail to England should stop."

I am to inform you that this statement is inaccurate. It is true that the British Post Office, like the Post Offices of the other principal European countries, is of opinion that the time has not yet arrived when ordinary mail can be sent

regularly by air and that it has explained this point of view to other countries. On no occasion, however, has this country refused to accept ordinary mail despatched to it by other countries by air, or asked that the despatch of such mail by air should cease. Such despatches were actually made by a number of night services during 1930 and no difficulty was raised about their acceptance.

At an Air Mail Conference held in Brussels in October last, which was summoned at the instance of this department, and at which all the countries referred to were represented, this point of view was made perfectly clear and a resolution confirming it as generally acceptable was unanimously adopted. The text of the resolution was as follows:—

> " The Committee is of opinion that in time air services will be comparable to rail and sea services from the point of view both of cost and of regularity. Air transport will then become one of the normal means of conveying letters and postcards.
>
> " The Committee is nevertheless of opinion that at present this is a more or less distant ideal, and that the principle of the surtax laid down in the Air Mail Section of the Convention should be maintained.
>
> " It recognises, however, the right of despatching countries to forward correspondence (letters and postcards) by air without surcharge at their discretion, subject to agreement with the countries of transit.
>
> " To countries whose air mail traffic is well developed, air conveyance without surtax offers serious practical and financial difficulties. These countries, while sympathising with the views expressed by countries whose traffic is less important, are not at present in a position to abolish the air surtax."

If, therefore, the statement referred to is made by Captain Florman in his lecture, I am directed to request the Royal Aeronautical Society to be good enough to make it clear that its accuracy is explicitly denied by the Postmaster-General.

I am, Sir, your obedient Servant,

F. A. WILLIAMSON.

The Secretary,
The Royal Aeronautical Society.

ABSTRACTS AND NOTICES
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Aircraft Design

Hodographs and Polars of Aircraft. (A. Magnan and A. Sainte-Laguë, Bull. Tech., No. 69, July, 1930, 67 pp.) (5.1/21001 France.)

When an aircraft is gliding steadily without power, for each inclination of the gliding path to the horizontal there is a corresponding air speed with horizontal and vertical components. Plotting the horizontal against the vertical component a curve is obtained which is defined as a *hodograph*. Certain useful quantities, such as the path of maximum horizontal velocity, path of longest glide, etc., can be found graphically. If there is a wind results are modified correspondingly. The method of measuring the speed of the aircraft from cinematograph records with a ruled framework of reference is illustrated by a reproduction of eight photographs from films.

Small Wind Tunnels and Aeroplane Design. (H. Glauert, J.R.Aer.Soc., Vol. XXXV, No. 243, March, 1931, pp. 207-230.) (5.102/21002 Great Britain.)

The corrections necessary for passing from a model to a full size aeroplane are discussed in detail. Elementary formulæ and graphical examples of corrections are given for the effect on tail-setting, down-wash, maximum lift, drag, thrust, choke velocity, etc. In the paper and in the discussion general agreement was expressed with what may be called " first order " corrections, but equally general doubt as to the residual errors. The discussion was specially valuable in eliciting the views of representative designers.

The Phenomenon of " Buffeting." (Airc. Eng., Vol. III, No. 24, February, 1931, pp. 31-34.) (5.11/21003 Great Britain.)

A new aeronautical term is introduced by the Accidents Investigation Sub-Committee in their report on the accident to the Junkers F.13 type aeroplane at Meopham, Kent. " Buffeting " is attributed to eddies given off by the wings at large angles of incidence and acting periodically on the tail.

Rationalisation of Aircraft Construction. (M. H. Bauer, Z.F.M., Vol. XXI, No. 24, 29/12/30, pp. 630-635.) (5.15/21004 Germany.)

The broad lines of the subject are laid down.

Aerodynamics for Engineers. (N. A. V. Piercy, Airc. Eng., Vol. III, No. 25, March, 1931, p. 67.) (5.15/21005 Great Britain.)

A series of six articles is concluded. They form a useful introduction to aeroplane theory.

Tests in Variable Density Tunnel to Investigate Scale and Turbulence Effects on Aerofoil Characteristics. (J. Stack, N.A.C.A. Tech. Note No. 364, February, 1931.) (5.2/21007 U.S.A.)

Artificial turbulence was introduced by a coarse screen of 5/16in. by 1/16in. steel strip, with 1½in. mesh, giving 1 3/16in. openings. Lift was measured against incidence for seven aerofoils at different Reynolds numbers, with and without the screen. The results are plotted and various conclusions are drawn.

The resistance of a sphere was measured as a standard of comparison.

Profile of Aerofoils, Effect of Small Variations. (K. E. Ward, N.A.C.A. Tech. Note No. 361, January, 1931, 18 pp.) (5.2/21008 U.S.A.)

Results are plotted for a pair of Göttingen and a pair of N.A.C.A. profiles, and show sensible differences in characteristics, greater than might be expected from the small geometrical differences in each pair.

Pressure Distribution Over Wings and Tail Surfaces. (R. V. Rhode, N.A.C.A. Rept., No. 364, January, 1931, 103 pp.) (5.25/21009 U.S.A.)

Photographs are given of the aeroplanes from various points of view, and of the installation of the test apparatus. The distribution of pressure orifices is given in dimensioned sketches and tables. Measurements were taken in (1) level flight, (2) pull-ups, (3) rolls, (4) spins, (5) inverted flight, (6) dives, (7) pull out of dive; and the results are tabulated and plotted graphically in several hundred diagrams.

Wing Flutter. (Air Corps Inf. Circular, Vol. VII, No. 653, 21 pp.) (5.26/21010 U.S.A.)

A general non-mathematical survey is made of the phenomena of forced vibrations in wings. The influence of natural periods, camber and dimensions is expressed in empirical formulæ. These are confirmed, it is stated, by German, Dutch and English results. The relations between frequency of vibration and air speed are given graphically for different incidences, positions of the elastic axis, mass distribution, and dimensions. The recommendations of Messrs. Fraser and Duncan are abstracted.

Pressure Distribution Over a Square Wing Tip on a Biplane in Flight. (R. V. Rhode and E. E. Lundquist, N.A.C.A. Tech. Note No. 360, January, 1931, 35 pp.) (5.2/21011 U.S.A.)

A specification is given of the Douglas M.3 biplane employed. Orifices in the wings were connected to measuring instruments maintained at constant temperature in an insulated compartment. The results are tabulated and plotted.

Load of Trailing Edge Flap. (R. M. Pinkerton, N.A.C.A. Tech. Note No. 353, October, 1930, 9 pp.) (5.22/21012 U.S.A.)

Author's Summary.—This report presents a theoretical analysis of the lift on a trailing edge flap. An analytical expression has been derived which enables the computation of the flap load coefficient. The theoretical results seem to show a fair agreement with the meagre experimental results which are available.

Aileron Effect on Wings, Theoretical Investigations. (C. Wieselberger, Aer. Res. Inst., Tokyo Impl. University, Rept. No. 30, December, 1927, 26 pp.) (5.31/21013 Japan.)

The circulation in a plane at right angles to the pitching axis at a given distance from the centre line is expressed as a Fourier series in terms of the eccentric angle of an ellipse with the span as major axis. The asymmetrical effect of the ailerons on circulation, lift resistance, pitching moment and yawing moment is expressed in a similar form. A number of coefficients is determined and the results are plotted graphically.

Interference and Drag of Struts on a Monoplane Wing. (H. E. Ward, N.A.C.A. Tech. Note No. 365, February, 1931, 17 pp.) (5.44/21014 U.S.A.)

A Göttingen No. 387 profile duralumin model was tested in the compressed air channel at Reynolds number 3,400,000 alone and with Navy No. 1 Section struts. The effects on the upper surface were more serious than on the lower surface in accordance with well-known experience, and in some cases doubled the profile drag. The results are given in numerical tables and graphically and are considered of sufficient importance to require further investigation.

International Wing Model. (Aer. Res. Inst. (Wind Tunnel Committee), Tokyo Imp. University, Rept. No. 66, December, 1930.) (5.2/21015 Japan.)

In accordance with the international comparison of test results R. and M. 954, a model wing of R.A.F. No. 15 profile was tested in six Japanese wind tunnels, of which dimensioned drawings are given. The velocity and pressure fields were explored and the lift-drag curves of the model were measured. The results are plotted and tabulated. No other international results are quoted, so that reference must be made to the reports of the other co-operating institutions for comparison.

Instrument for Conformal Transformation. (S. Gerschgorin, Z.F.M., Vol. XXI, No. 15, 18/8/30, pp. 391-393.) (5.2/21016 Germany.)

An elaboration of the elliptic compass gives a comparatively simple linkage by means of which Joukowski profiles can be drawn mechanically. The elementary geometrical theory is given.

Torsion in Box Wings. (N.A.C.A. Tech. Note No. 366, February, 1931, 46 pp.) (5.25/21017 U.S.A.)

Eight methods of design are summarised, and the results of calculation, compared in a table, show that the method which is stated to be in present use in U.S.A. gives a result roughly twice as much as the method of least work. The analysis arising in the various methods is given in some detail with numerical examples.

Testing Aeroplane Controls. (H. L. Stevens, J.R.Aer.Soc., Vol. XXXV, No. 242, February, 1931, pp. 96-120.) (5.35/21018 Great Britain.)

The author attempts to co-ordinate the sensations and muscular reactions of the pilot with the aerodynamics of control surfaces, with a view to removing from test reports descriptive adjectives and replacing them by quantitative numerical statements. The principal troubles arising during flying are discussed and methods of dealing with them are suggested. Both the paper and the discussion illustrate the tendency of the pilot to ascribe a personality to aircraft and the difficulty of regarding them in the cold light of mechanical reasoning.

Stresses in Wired Wheels. (A. J. Sutton Pippard and W. E. Francis, Phil. Mag., Vol. XI, No. 69, February, 1931, pp. 233-283.) (5.55/21019 Great Britain.)

A complete solution is obtained in terms of elementary functions and a number of values are tabulated for cases of a practical nature. Numerical examples are given with the pound weight as a unit of force. The complete formula being extremely laborious to compute, the approximate formulæ are developed which cover the more usual cases. A graphical comparison with experiment shows measured stresses somewhat exceeding calculated stresses.

Landing Gears, Rubber Cord and Oleo Rubber Disc; Tests. (W. C. Peck, N.A.C.A. Rept. No. 366, February, 1931, 19 pp.) (5.55/21020 U.S.A.)

The oleo gear was found slightly superior up to vertical drops of 16in. with maximum acceleration of 3.6 g. Rubber cord gear was increasingly superior from 16in. drop to 22in. drop, at which the stops prevented further travel. Beyond 22in. drop oleo gear withstood drops up to a total of 37in. Photographs are given of both types, and a sketch of the oleo gear. Graphical plotting yields faired curves, with considerable scattering of the observed points in some cases. The records of the oleo cylinder pressure show marked harmonic oscillations superposed on the whole pressure record.

Seventeen references are given.

Safety in Flying and Caterpillar Undercarriages. (Th. Chevalley, Aero. Rev., No. 2, 15/1/31, pp. 9-10.) (5.58/21021 Switzerland.)

The caterpillar landing wheel has an equivalent wheel diameter of 30ft., with small air resistance in flight. The specific loading is reduced, ground inequalities are easily surmounted, and nose dive on landing is practically impossible. Powerful brakes can be fitted without danger of capsizing. A French caterpillar developed during the last four years is described.

Seaplanes, Floats, Etc.

Alighting of Seaplanes. (H. Wagner, Z.F.M., Vol. XXII, No. 1, 14/1/31, pp. 1-8.) (5.56/21022 Germany.)

A number of diagrammatic semi-empirical representations are given of the motion of water under the impact of the float or hull, the velocity field being partly determined by more or less plausible assumptions. Once the assumptions have been admitted the mathematical development of the consequences may be accepted. The results obtained in this way are exhibited graphically and applied to the working out of a numerical example.

Alighting Shocks of Seaplanes. (W. Pabst, Z.F.M., Vol. XXII, No. 1, 14/1/31, pp. 13-27, 202nd D.V.L. Report.) (5.56/21023 Germany.)

Two types of instrument are applied, one a pressure indicator let into the bottom of the float or hull, and the second a strain indicator attached to the struts of the landing carriage. The former is actuated by the bending of a flat circular plate under hydraulic pressure, while the latter acts on the usual extensometer principle and records the deflection by scratching a glass plate with a diamond. A semi-empirical theory of the mass of water displaced and its effect on impact pressures is developed. The tests as a whole are incomplete, but on developing the results with the aid of various assumptions and filling in the gaps from general experience a set of graphical representations is obtained which compares reasonably well with the assumptions made by D.V.L. The tabulated experimental results take up three pages of the report.

Dynamical Similitude Applied to the Starting of Seaplanes. (P. Schröder, Z.F.M., Vol. XXII, No. 1, 14/1/31, pp. 8-12.) (5.56/21024 Germany.)

In comparing starting tests on models and full-scale machines it is found that, in addition to maintaining geometrical similarity of surface, position of c.g., attitude and gliding angle, the square of the velocity must be proportional to the total load. This is tested experimentally and the results are exhibited graphically, the fulfilment of the above condition giving a universal experimental curve for a variety of loads. When this condition is not observed it is necessary to determine two functional conditions, one connecting the incidence with the gliding angle and the ratio velocity^2/total load; and another connecting the trimming moment with the same quantities. When these are determined it is possible to compare the whole range of starting conditions. Examples are given graphically.

Airscrews

Strength of Thin Metal Airscrews. (P. A. Ralli, J.R.Aer.Soc., Vol. XXXV. No. 242, February, 1931, pp. 121-166.) (5.654/21025 Great Britain.)

The author, who designed the airscrews for the high speed Schneider Cup machines, gives a complete method of designing thin blades in which the centrifugal forces partially balance the thrust forces. In the numerical working out nineteen pages of tabulated figures are given. These are represented in ten graphs. Dimensions of blade sections at twelve sections are given, with workshop instructions.

Design of Airscrews and Comparison with Tests. (R. Seiferth, Z.F.M., Vol. XXII. No. 3, 14/2/31, pp. 72-76.) (5.650/21026 Germany.)

A series of model airscrews was tested in the wind channel. Their characteristics were calculated from the simplified theory of Prandtl and von Kármán for airscrews of small pitch and the calculated thrust was larger than the experimental thrust by 5 to 15 per cent., according to the loading.

Controllable Pitch Airscrew. (W. Turnbull, J.R.Aer.Soc., Vol. XXXV, No. 243, March, 1931, pp. 231-244.) (5.658/21027 Great Britain.)

The advantages of a variable pitch airscrew are illustrated by graphical representations of improvement in performance. The disadvantages of weight and complication are considered.

The Benuzzi Variable Pitch Airscrew. (Z.F.M., Vol. XXI, No. 21, 14/11/30, p. 571.) (5.659/21028 Germany.)

Each blade consists of a series of segments threaded on two steel tubes and covered with duralumin sheet. Movement of the rear tube relative to the leading tube rotates the segments and alters the incidence.

Instruments

Present Status of Aircraft Instruments. (N.A.C.A. Rept. No. 371, December, 1930.) (6.0/21029 U.S.A.)

The report covers the whole range of instruments fitted to aeroplanes for every purpose. Twenty-two problems under investigation are listed and forty-six references are given.

A Portable Three-Component Vibration Meter. (J. Sci. Insts., Vol. VIII, No. 1, January, 1931, pp. 29-31.) (6.26/21030 Great Britain.)

A photograph with numbered parts illustrates a description of the mechanism. Three dead-beat lever arms record components of vibrations on locomotives and rolling stock. Two additional pens make time marks. The portable case measures 440 × 250 × 260 mm.

D.V.L. Torsiograph for Measuring Torsional Oscillations in High Speed Engines. (A. Stieglitz, Z.F.M., Vol. XXII, No. 2, 28/1/31, pp. 49-52.) (6.271/21031 Germany.)

The D.V.L. torsiograph is neat and easily attached to the crankshaft. A steel pointer records accurately on a celluloid strip time and rotation of the shaft, and the frequency of the oscillation can be obtained to the same order. The instrument appears to mark a noticeable advance.

A bibliography includes the R.A.E. torsiograph, which records optically.

New Optical Indicator for High Speed Engines. (J. Kluge (Abs. F. Nakanishi, Japan), F.G.I., Vol. II, No. 2, February, 1931, p. 82.) (6.44/21032 Japan.)

A new optical indicator by F. Nakanishi (J. Soc. Mech. Eng. (Japan), foreign edition, Vol. XXXIII, p. 86) is described. Vibration of the instrument as a whole does not affect the optical record, so that high magnification can be employed. The motion of the indicator piston is controlled by a beam spring. Two recording mirrors are attached to this beam so that a ray of light from the point source travels from one mirror to the other along the cantilever before it is reflected back on the recording drum. The frequency of the instrument is stated to be of the order of 10,000 per sec., and the motion of the piston 1,000th of a mil. per atmosphere.

No reference is made to calibration difficulties brought about by changes in temperature.

Development of the Distance Reading Compass and its Importance in Automatic Control. (W. Möller, Z.F.M., Vol. XXI, No. 24, 29/12/30, pp. 640-645.) (6.505/21033 Germany.)

The selenium compass, the earth inductor and pneumatic distant reading compass of the Askania Works are described. The selenium compass used in Germany during the latter part of the war is obsolete. The earth inductor as applied to aircraft is considered satisfactory. The best results have been obtained with a pneumatic compass fitted with a servo-motor and gyro-damping to operate the rudder automatically. The aileron control is inter-connected by a pendulum so as to compensate for departure from the horizontal. Pneumatic compasses have operated successfully for 300 working hours.

A Modification of the "Gerrish" Drive. (F. J. Hargreaves, J.B. Astr. Assoc., Vol. XLI, No. 3, January, 1931, pp. 112-115.) (6.3/21034 Great Britain.)

In the "Gerrish" chronograph drive the pendulum controls the current of a driven electro-motor on the principle of supplying alternately too much or too little current. The modification works on the principle of applying brake friction alternately in defect and in excess. It is stated that both arrangements give satisfactory accuracy.

Stability and Control

Behaviour of Conventional Aeroplanes in Engine Failure and in Stalled Landing (F. E. Weick, N.A.C.A. Tech. Note No. 363, February, 1931.) (7.2/21035 U.S.A.)

Handling experiments were carried out with twelve aeroplanes. The velocity is plotted against time from cutting out of engine for all the different conditions. It is concluded that most accidents are due either to striking the ground while still in a turn or to development of a spin.

Investigation of Curved Flight. (H. Kruse, Z.F.M., Vol. XXII, No. 2, 28/1/31, pp. 37-44.) (7.2/21036 Germany.)

Expressions are obtained for the modified characteristics of an aeroplane. The results are exhibited in ten diagrams and fourteen tables. A number of curved flights were carried out on a full-sized aeroplane, and the time required for each manœuvre, with given control surface settings, was compared with the calculated times. The worst discrepancy was 25 per cent. The other observed figures agree very reasonably with the calculated figures.

Longitudinal Stability of Canard Type. (H. G. Kiel, Z.F.M., Vol. XXI, No. 23, 15/12/30, pp. 601-610.) (7.25/21037 Germany.)

The usual methods of aerodynamical stability are applied. A number of criteria are obtained, and the results are exhibited graphically in twenty-one diagrams.

Air Transport in Fog. (F. W. Meredith, J.R.Aer.Soc., Vol. XXV, No. 242, pp. 75-95.) (7.8/21038 Great Britain.)

The paper discussion covers nearly every aspect of the present position in regard to equipment for flying and landing in fog.

Engines—Fuels, Lubricants, Etc.

A New Method of Determining Heat Transmission Coefficients. (L. Kettenacker, T.M.T., Vol. I, No. 12, December, 1930, pp. 439-440.) (8.1/21039 Germany.)

Heat transfer coefficients have generally been determined by direct measurements of heat flow. This often requires rather elaborate apparatus, and the author suggests a new method of measuring the coefficient indirectly. A model of the apparatus for which the transfer coefficient is required is made in porous clay and filled with water. The heat transfer is estimated by the amount of water evaporated.

Thermal Conductivity of Gases: Christiansen Three-Plate Method of Determination. (H. Dierkes, Phys. Zeit., Vol. XXXII, No. 2, 15/1/31, pp. 84-91.) (8.1/21040 Germany.)

The guard ring method of Christiansen for air, hydrogen and carbon dioxide is subject to inherent errors and should no longer be quoted.

Compensated Thermopile. (J. Guild, J. Sci. Insts., Vol. VIII, No. 1, January, 1931, pp. 14-17.) (8.1/21041 Great Britain.)

Two "Moll" large surface thermopiles, each with eighty manganin-constantan junctions, are erected in opposition. One only is exposed to the radiation it is desired to measure, the other being protected by diaphragms. The resistance is doubled, but the compensation reduces the cooling and heating effects of disturbances in the surrounding air to one-fiftieth. Residual e.m.f., due to temperature changes in the laboratory, is eliminated. The compensated pile may be used without any further screening for determination of faint radiation requiring high sensitivity and precision.

Benzine-Air Explosions, Extinction by Carbon Tetrachloride. (A. H. Belinfante, Chem. Weekblad., 1931, 28, 2-19. Chem. and Industry Abstracts, p. 188, Vol. L, No. 9, 27/1/31.) (8.1/21042 Great Britain.)

The high boiling point of carbon tetrachloride requires a fairly high concentration to suppress explosions of benzine mixtures Generally, on passing a spark, a certain amount of hydrochloride acid is formed.

Heat Transmission to Water Flowing in pipes. (A. E. Lawrence and T. K. Sherwood, Ind. and Eng. Chem., Vol. XXIII, No. 3, 1/3/31, p. 301.) (8.1/21043 U.S.A.)

Experiments were carried out on heating water flowing through a copper tube .6 inch inside diameter by condensing steam on the outside, at speeds from ½ to 22ft. per sec. Thermocouples determined the pipe surface temperature and the average deviation of the heat balance was less than 7 per cent. The film coefficients for condensing steam on the outside of a pipe were found to agree with Nusselt's formula, and were substantially independent of the effective pipe length.

Ignition Limits of Hydrogen-Air Mixtures. (Fr. Dieterlen, T.M.T., Vol. I, No. 12, December, 1930, pp. 429-434.) (8.11/21044 Germany.)

From optical indications and spark photographs of the flame front it appears that combustion of hydrogen air mixtures can be propagated, although the temperature of combustion is less than the ignition temperature. The intensity of the ignition spark is important. On repeated sparking at intervals of a few seconds, mixtures were finally ignited, in contrast with Coward's experiments. (J. Am. Chem. Soc.)

Combustion of Inflammable Gases by Electric Sparks. (J. D. Morgan, Phil. Mag., No. 68, January, 1931, pp. 158-163.) (8.13/21045 Great Britain.)

Under a succession of electric sparks in a gas mixture not ignited or inflamed by the sparks, the amount of combination of the constituents is proportional to the heat energy of the spark discharge with gap width constant, and over a wide range of the gap width with heat energy constant; from these and earlier experiments combustion, as well as ignition, depends on the heating of the gas by conduction.

Recording Gas Calorimeter. (Z.V.D.I., Vol. LXXV, No. 2, 10/1/31, p. 52.) (8.14/21046 Germany.)

Gas and air in constant proportions are burnt at a definite rate in a pyrometer. The temperature of the tube is estimated by its expansion, which is recorded on a rotating drum and gives consistent results under practical conditions. The temperature is a measure of the energy of combustion.

A New Electrical Indicator. (K. Schnauffer, Z.V.D.I., Vol. LXXIV, No. 30, 26/7/30, pp 1066-1067. See A. and N. 15/13155.) (8.22/21047 Germany.)

The pressure acting on one of the plates of a condenser alters the air gap and the electrical capacity. These changes are amplified and recorded on an oscillograph. Examples of indicator diagrams are given.

Difficulties due to thermal expansion in calibration and in fixing the zero point are not considered.

Piezo Electric Indicator for High Speed Combustion Engines. (J. Kluge and H. E. Linckh, Z.V.D.I., Vol. LXXIV, No. 25, 21/6/30, pp. 887-889.) (8.22/21048 Germany.)

A form of piezo electric indicator is described working with a valve amplifier and an electro-magnetic cinograph. From pressure diagrams on a time scale the work done per cycle is obtained by a harmonic analyser.

Heat Transfer in Sparking Plugs. (H. Rabezzana, Autom. Ind., Vol. LXIV, No. 4, 24/1/31, pp. 120-121.) (8.283/21049 U.S.A.)

It is necessary to keep the sparking plug insulator at a temperature high enough to burn off any carbon deposited, but not high enough for pre-ignition.

The plug should reach its normal temperature quickly, since a cool plug is liable to become covered with carbon during the start. These various requirements can be met by reducing the size of the plug and the weight of the insulator. Small plugs warm up more quickly than normal size plugs and their maximum temperature is less. Particulars are given of small plugs on the market.

Low Price Engine for Light Aircraft. (Autom. Ind., Vol. LXIV, No. 4, 24/1/31, p. 131.) (8.25/21050 U.S.A.)

Four-cylinder air-cooled horizontally opposed double twin, cubic displacement 155 c. inches, rated 35 h.p. at 2,500 r.p.m., weight 138lbs. complete. The L-head cylinders are cast in pairs. The crankcase is rigid and conforms to the nose of the aircraft. The carburettor is attached to the lowest part of the crankcase, both oil cooling and heating of the charge being obtained by passing the induction pipe through the oil sump.

Ganz-Jendrassik Diesel Engine. (Aut. Tech. Zeit., Vol. XXXIV, No. 4, 16/2/31, p. 103.) (8.25/21051 Germany.)

The two-stage principle is applied. The pre-ignition chamber is placed in the cylinder head and the fuel issues in the direction of the cylinder axis and meets a special atomiser plate fastened to the cylinder crown, the process combining the advantage of two-stage ignition and of direct injection. The engine is insensitive to nature of fuel, starts cold and has medium compression ratio. The design has been applied mainly to rail transport, but is being adapted to automobiles.

The Deeble Duplex Engine. (N. French, Aero Digest, Vol. XVIII, No. 1, January, 1931, p. 76.) (8.25/21052 U.S.A.)

This engine consists of two pistons, one working inside the other one. The inner piston is stationary, the outer one being reciprocated. Two combustion chambers are thus obtained, one above the other. A weight of under 1 kg./h.p. is claimed in the case of the air-cooled six-cylinder model rated at 300 h.p.

Range of Aircraft with Diesel Engines. (J. D. Coales, Airc. Eng., Vol. III, No. 25, March, 1931, pp. 61-62.) (8.265/21053 Great Britain.)

Approximate formulæ are developed of sufficient accuracy to determine the range within practical limits for specific weight, specific consumption, efficiency of engine, total weight of fuel carried, maximum lift-drag ratio of the complete aeroplane, and the total flying weight.

A numerical example is worked out taking representative weights and consumptions of a petrol engine and a compression ignition engine. The ranges become equal at 1,210 air miles, but the compression ignition engine has a slight advantage in mean speed, 94.2 m.p.h. compared with 91.5 m.p.h.

A table gives specifications and figures of equal range for seven standard types of aircraft fitted alternatively with petrol and compression ignition engines. It is remarkable that the compression ignition engine equals the performance of a petrol engine for an aircraft weighing 17,650lbs. only after flying 1,136 air miles in 15 hours; while for a water-cooled bomber of 9,486lbs. total weight, equality of range is only obtained at 2,060 air miles in 26 hours. These figures, closely based on experimental data, are less favourable to the compression ignition engine than previous estimates.

A Compressorless Diesel Engine. (F. Schmidt, Z.V.D.I., Vol. LXXIV, No. 33, 16/8/30, pp. 1151-1154.) (8.291/21054 Germany.)

The experimental 22 h.p. single-acting, four-stroke M.A.N. engine has a single cylinder of 210 mm. bore and 300 mm. stroke and a compression ratio

of 11. The inlet valve is masked so that the turbulence can be adjusted to the most complete combustion. The friction losses increase rapidly with speed. Below 300 r.p.m. cooling losses increase the specific fuel consumption.

Device for Observing Phenomena of Injection in Compressed Air. (M. Clerget, C.R., No. 9, 2/3/31, pp. 553-555.) (8.296/21055 France.)

In developing the Clerget oil injection engine, fuels injected into a closed vessel, effectively scavenged after each injection, were photographed stroboscopically with short exposures. At 1,040 r.p.m. the total injection time was 1/360 second. The mean speed of penetration was 130 m. per sec. with air at one atm. and 32 m. per sec. at 28 atm. The pump injection pressure throughout was 200 atm. The rate of growth of the jet sensibly follows the profile of the pump cam.

Life of High-Speed Engine Pistons. (Modersohn (Abst.), Z. fur Metallk., Vol. XXIII, No. 2, February, 1931, pp. 67-68.) (8.32/21056 Germany.)

The surface of the material should be as smooth as possible, since this largely determines the life of the piston. Cold working and so-called " press finish " should be applied to the parts.

Torsional Strength Measurement. (Autom. Ind., Vol. LXII, No. 22, 31/5/30, p. 828.) (8.36/21057 U.S.A.)

Prandtl has shown (Love's Elasticity, para. 224) that the contours, under internal pressure, of a soap film spread over the plane end of a thin pipe are identical with the lines of equal shear under torsion at corresponding points in a long solid cylinder of the same external contour as the pipe. The use of the method has been found economical by the U.S. Bureau of Standards.

Fractures of Crankshafts. (K. Matthaos, L.F.F., Vol. VIII, No. 4, 28/7/30, pp. 91-120.) (8.36/21058 Germany.)

Typical fractures are illustrated by nineteen photographs. Micro-photographs of etched surfaces indicate the grain of the materials. The mechanical qualities of the materials are discussed and numerical values are tabulated. The increased stresses due to bad shape of parts and to resonance oscillations are referred to.

Critical Speeds of Multiple Shafts. (J. J. Ryan, J. Franklin Inst., Vol. CCXI, No. 2, February, 1931, pp. 151-196.) (8.36/21059 Great Britain.)

A multiple shaft is defined as a continuous shaft formed by the alignment of the rotating elements of several machines in which the unit shafts are rigidly coupled. Differential equations are formed in the usual manner for rigid bearings with modifications for flexible bearings. Numerical examples are worked out, tabulated and graphed. Ten references are given.

Recent Developments in Engine Cooling. (A. Swan, J.R.Aer.Soc., Vol. XXXV, No. 243, March, 1931, pp. 179-206.) (8.44/21060 Great Britain.)

Cooling by liquids of higher boiling point than water is briefly discussed, *e.g.* ethylene glycol, b.p. 197°C., and glycerine, b.p. 290°C. Graphical records are given of pumping tests at different temperatures for these two substances, their viscosity at low temperatures being 17 and 600 times that of water at 25°C., but less than that of water above 100°C.

Charts are given of temperature differences from air to cooling liquid over the range of working conditions.

Evaporative cooling is discussed at some length, with diagrams of a circulating system and a photograph of an aeroplane installation. Some figures of results are given.

A note is added on oil cooling. Experimental figures of heat transfer are given, and diagrammatic drawings of two coolers are reproduced.

The discussion and replies brought out a number of practical experiences and experimental data.

Resistance and Cooling Effect of an Aeroplane Body with Various Arrangements of Radiators. (H. Muttray, Z.F.M., Vol. XXII, No. 3, 14/2/31, pp. 65-73.) (8.422/21061 Germany.)

Model experiments were carried out on the efficiency of frontal, side and underbody radiators. Each design has relative advantages and selection depends on particular considerations. The underbody radiator can be retracted out of the slipstream where great variation in cooling is required, while blanking off other types by shutters increased the resistance.

In changing from climbing to horizontal flight a Junkers A.35 underbody radiator set up considerable buffeting by changing the type of air flow.

The Air Resistance of Air-Cooled Radial Engines. (F. N. Scheubel, Z.F.M., Vol. XXII, No. 3, 14/2/31, pp. 72-73.) (8.426/21062 Germany.)

The experiments were confined to a Jupiter cylinder with various forms of cowling. The resistance of a single cylinder was reduced to $\frac{1}{3}$rd, but the effect on heat transfer may be unfavourable and requires further experiment.

Foaming. (Autom. Ind., Vol. LXII, No. 22, 31/5/30, p. 836.) (8.54/21063 U.S.A.)

The cause of foaming of lubricating oil is the larger suction of the scavenging pump, which receives the oil delivery from the pressure pump. The rest of its capacity is made up by air, which becomes intimately mixed with the oil in minute bubbles. Additional bubbles may be formed by the splashing of the return oil into the oil in the tank. These bubbles reduce the oil pressure. Oil foaming will occur more readily under the following conditions: (1) hot oil, (2) small quantity in tank, (3) short oil return line, (4) engine having numerous scavenge pumps and a small sump, and (5) high oil tank.

The air bubbles are effectively separated by discharging the oil on to a sloping plate so that it runs down the sides into the oil in the tank.

Lubricating Oil. (J. Tausz and A. Staab, Petroleum, 1930, 26, 1117-1124, 1129-1140. Chem. and Ind. Abstracts, p. 187, Vol. L, No. 9, 27/2/31.) 8.54/21064 Great Britain.)

The molecular weights of a number of oils have been determined, using different solvents. Mineral oils generally show an increase of molecular weight with increased concentration. Vegetable oils show a decrease.

On mixing benzine with a mineral oil there is a marked increase in volume; with castor oil there is a small decrease.

Observations on the Testing of Lubricants. (E. Wooler, S.A.E., Vol. XXVIII, No. 1, January, 1931, pp. 53-65.) (8.54/21065 U.S.A.)

Gear tooth pressures and rubbing speeds beyond safe lubrication by petroleum distillates can be supported by a lead soap base, but fairly rapid wear cannot be prevented. If the fluid film is ruptured the high spots on the bearings which with a normal lubricant would lead to seizure, are worn away rapidly by a combination of chemical action and abrasion. Film lubrication over the full bearing area is thus restored.

Effect of Rubbing Speed on Lubricating Oil. S.A.E., Vol. XXVIII, No. 2, February, 1931, p. 258.) (8.54/21066 U.S.A.)

Lubricants that pass the ordinary journal bearing test at 100 r.p.m. often fail at lower speed. Possibly the higher temperature of the oil at the higher speed produces chemical action between journal pin and lubricant.

Lubricating Oil. The Effect of Oil Consumption and Temperature on Octane Numbers and Ratings. (H. R. Stacey, Annual Meeting of S.A.E., S.A.E. Jrnl., Vol. XXVIII, No. 2, February, 1931, p. 255.) (8.54/21067 U.S.A.)

The possible error arising from different rates of consumption and variations of temperature may reach one octane number. The type of oil does not materially affect the results. The oil consumption should be kept down to the minimum for safety, and the oil temperature should be kept constant at the lowest value consistent with good lubrication.

Production of Fuel and Lubricant Oils by Hydrogenation. (R. T. Haslam and W. C. Bauer, S.A.E., Vol. XXVIII, No. 3, March, 1931, pp. 307-314.) (8.5/21068 U.S.A.)

Three important effects are:

(1) Purification, by elimination of sulphur, nitrogen and oxygen as gaseous hydrides;
(2) Stabilisation; highly stable carbons are formed at the expense of less stable molecules;
(3) Decomposition of asphaltic, resinous and hydro-carbons, with formation of a more homogeneous oil.

Prevalence of paraffins determines a product suitable for lubrication, and prevalence of naphthenes a product suitable for combustion with anti-knock properties. Extensive tables and diagrams are given of the results of hydrogenation on a commercial scale.

Production of Motor Fuels containing Alcohol. (K. R. Dietrich, Chem. and Ind., Vol. L, No. 11, March, 1931, p. 232.) (8.604/21069 U.S.A.)

Directions are given for mixing fuels with alcohol so as to ensure stability. The most common mixture is 20 per cent. absolute alcohol, 30 per cent. benzol and 50 per cent. petrol, by weight. A table is given of the cc. water which can be added to 100 cc. motor fuel before the mixture becomes cloudy.

Oxidation of Fuels in Motors. (E. Berl, K. Heise and W. Winnaker, Chaleur et Ind., Vol. X, 1929, pp. 179-187, 241-246. Chem. Absts, Vol. XXV, 20/2/31, p. 806.) (8.64/21070 Germany.)

Hydro-carbons rich in H_2 decompose into H_2 and non-saturated hydro-carbons, which absorb O_2 forming H_2O_2, water and organic peroxides.

Present Position of Testing of Aero Engine Fuels. (A. v. Philoppovich, Z.F.M., Vol. XXII, No. 2, 28/1/31, pp. 47-49; and No. 3, 14/2/31, pp. 80-84, 203rd D.V.L. Rpt.) (8.640/21071 Germany.)

A fuel can be analysed into aromatics, naphthenes and paraffins and the toluene value calculated. This method gives rough results and is not applicable when metallic dopes are present. The determination of the self-ignition temperature of the fuel depends on the apparatus used, and the values are not generally applicable. The correlation of the self-ignition temperature with other physical properties has been proposed. Brown and Watkins take the pressure rise in a bomb divided by the self-ignition temperature as a figure of merit. Neither this

nor correlation of the self-ignition temperature with the rate of admission of oxygen to the ignition pot provided a satisfactory rating. The oxidation tendency of the fuel at temperatures below self-ignition has not given consistent results. The conclusion is that no laboratory tests can take the place of engine tests in determining the suitability of a given fuel. The cylinder temperature speed, and stroke volume of the test engine should approximate to the engine used in practice. Ricardo's method of determining absolutely the highest useful compression ratio has been replaced by matching fuels. Mild continuous detonation is obtained with the fuel under test, and with a mixture of two standard constituents possessing varying detonating characteristics, blended to give equal detonation, judged either by ear or by the bouncing pin. No satisfactory apparatus for use in flight has been devised. Detonation increases the thermal and mechanical loading of the engine. Valves and sparking plugs suffer especially under intense detonation, but no data are available on the effects of medium detonation over a short period, nor of continuous mild detonation over a long period.

Sixteen references are given.

Standardisation of Fuel. (Autom. Ind., Vol. LXII, No. 22, 31/5/30, p. 834.) (8.64/21072 U.S.A.)

The American Air Corps in future will specify a standard fuel and will rate engines by the power produced with specified maximum fuel consumption, at specified density of the carburettor air intake according to performance requirements. The purpose is that engines shall be designed to suit fuels rather than fuels selected to suit engines. Rating engines at a definite maximum allowable consumption will discourage the practice of cutting engine weight at the expense of fuel consumption.

On the Formation of Gums in Fuels. (R. Brunschwig and L. Jacqué, C.R., Vol. CXCI, No. 22, 1/12/30, pp. 1066-1068.) (8.64/21073 France.)

The effect of light on gum formation may be considerable under laboratory conditions, but in practice the fuel is usually stored in opaque tanks. Discoloration of a stored fuel is not a measure of gum formation.

Detonation. (N. A. Butkov, Trans. Thermo-Tech. Inst., Russia, 1930, No. 2, 41-44. Chem. Abst., Vol. XXV, No. 2, 20/1/31, p. 406.) (8.645/21074 Russia.)

The fuel under test was heated in a bomb with oxygen under pressure at 250° for 90 mins., under 5 atmospheres. Generally the fuels most resistant to oxidation had the highest anti-knock value in engine tests. The oxidation of mixtures differs considerably from the oxidation of the constituents separately.

Knock Testing with a Microphone. (Autom. Ind., Vol. LXIII, No. 26, 27/12/30, p. 946.) (8.645/21075 U.S.A.)

A microphone suspended on coiled springs near the test engine picks up all local noises, converting the sound pulsation into electric current. Pulsations corresponding to ordinary engine noises are then filtered out by what are technically known as "high-pass" filters, only the characteristic sound vibrations of knocking with a frequency of about 3,000 per second, passing on to the vacuum tubes. The electric current pulsations are magnified several hundred times and passed through a milli-ammeter, the readings of which are a measure of the intensity of the knock.

Anti-Knock Fuels. (L. Edeleanu and W. Grote, Brennstoff Chem., 11, 212-4, 1930. Chem. Abst., 20/1/31, p. 407.) (8.645/21077 Germany.)

By refining and blending, mixtures having high anti-knock value can be obtained. The results obtained by mixing fractions below 175° with higher boiling fractions from liquid sulphur-dioxide are similar to those obtained by adding a metallic dope.

Wheeler-Schebler Carburettor with New Metering Principle. (Autom. Ind., Vol. LXIII, No. 26, 27/12/30, p. 938.) (8.701/21078 U.S.A.)

The metering of the fuel delivered by the main jet is regulated by a pin operated by a suction controlled piston.

The advantage claimed over metering under direct throttle control is the possible use of a leaner "economy" mixture, with better part-throttle performance and freedom from low-speed lean spots.

Fuel Measuring Pump Pressures and their Effects on Performance. (J. Canoose, J.Am.Soc.N.Eng., Vol. XLV, No. 1, February, 1931, pp. 1-31.) (8.741/21079 U.S.A.)

Indicator cards of the pressure in pump cylinder, suction receiver, and suction line give useful information on the relative merits of the float chamber, the suction standpipe and the suction system without surge control. They show the superiority of the float chamber for surge control. The pumps should be rigid, the fuel leads should have the same flow resistance, and the discharge valve springs the same initial compression.

Anti-aircraft Ranging, Etc.

American Anti-Aircraft Guns. (E. C. Nichols, Sci. Am., Vol. CXLIV, No. 2, February, 1931, pp. 81-84.) (9.12/21080 U.S.A.)

A descriptive account with five photographs and a diagram, is given of the anti-aircraft equipment of the U.S. army, and of some of the results obtained in practice. Photographs are also given of a small mortar and a medium tank.

Photographic Method of Controlling Air Bombing Practice. (Capt. Billard, Rev.F.Aer., No. 17, December, 1930, pp. 1449-1474.) (9.33/21081 France.)

Aircraft are photographed from the ground on a recording theodolite. No bombs are dropped but readings on the bomb sights and the instant of release are signalled to the ground. The position of the aircraft on the photographic record and the readings on the bomb sight are correlated, and the probable accuracy is estimated.

Materials

Strength of Rectangular Flat Plates under Edge Compression. (L. Schuman and G. Back, N.A.C.A. Rept. No. 356, January, 1931, 24 pp.) (10.1/21082 U.S.A.)

Plates of duralumin, stainless iron, monel metal (65 per cent. Ni., 32 per cent. cu., plus Fe. Mn. Si. Zn.), and nickel (99 per cent.) were tested for buckling under edge loading. Sketches and photographs exhibit the testing machine and the corrugations of the specimens buckling under end loads. The stress-strain curves are exhibited graphically, as also the observed corrugations on the various test specimens. The departure from the observed maximum load did not exceed 50 per cent. for duralumin and 20 per cent. for monel metal.

Influence of High Frequency Oscillation on Metallurgical Treatment. (G. Mahoux, Rev.S.G.A., February, 1931, p. 8.) (10.12/21083 France.)

Subjection of a steel to high frequency mechanical oscillations, during nitration in a stream of ammonia, produced more rapid and intense hardening.

Some Properties of Protective Films on Metals. (E. S. Hedges, Chem. and Ind., Vol. L, No. 2, 9/1/31, pp. 21-25.) (10.125/21084 Great Britain.)

Anodic or potassium chromate treatment of iron forms a protective film of iron oxide which under certain conditions can be isolated.

Fourteen references are given.

Initial Corrosion Rate of Steels. (H. O. Forrest, B. E. Roetheli and R. H. Brown, Ind. Eng. Chem., Vol. XXII, No. 12, December, 1930, pp. 1197-1199.) (10.125/21085 U.S.A.)

The initial rate of corrosion of stainless steel is the same as that of other steels, but the rate of corrosion falls off rapidly and ceases in a few minutes with the formation of a protective film.

Protective Coatings of Aluminium Foil. (Z. fur Metallk., Vol. XXIII, No. 2, February, 1931, pp. 66-67.) (10.125/21086 Germany.)

A method of cementing 0.003in. aluminium foil on steel plates has been developed in America with some success as a protection against corrosion. The process has been used mainly in protecting the inner and outer surfaces of fuel tanks in the oil industry. The composition of the cement is not stated.

Outdoor Corrosion of Zinc and Cadmium Coatings on Iron and Steel. (C. L. Hippensteel and C. W. Borgmann, Bell Tele. Lb., No. B.516, November, 1930.) (10.262/21087 U.S.A.)

A description is given of the methods of applying natural and artificial atmospheric conditions. Specifications are given of the method of plating, and the rate of corrosion measured by loss of weight is exhibited in four graphs. The most resistant coating was a zinc alloy with 5 per cent. cadium.

Fatigue Strength of Welded Steel Joints. (W. Hoffmann, Z.V.D.I., Vol. LXXIV, No. 46, 15/11/30, pp. 1561-1564.) (10.14/21088 Germany.)

Specifications are given of seven steels which were investigated, in tabular form with the usual test figures. The variation of strength of the welded steel tubes, Nos. 1 and 3, is given graphically, and the mean values of twenty tests are tabulated for all seven materials. Micro-photographs are given of seven specimens, and two photographs of fractures near the weld.

Report of Conference on Wire Cable Research. (Z.V.D.I., Vol. LXXV, No. 7, 14/2/31, pp. 206-209.) (10.162/21089 Germany.)

The experiments deal mainly with the strength of joints under fatigue. Corrosion has an ultimate effect on life and depends largely on the composition of the steel. Government regulations limit phosphorous and sulphur content to 5 per cent. in cable for lifting machinery, but from the experiments it appears that this is no criterion for the stability of the wire cable.

Cast Aluminium in Compression Ignition Engine Construction. (W. Hartl, Aut. Tech. Zeit., Vol. XXXIV, No. 4, 16/2/31, pp. 94-98.) (10.231/21090 Germany.)

Ample ribbing is required to give rigidity to light alloy castings. Sharp regressive corners must be avoided. Silicon alloy castings are suitable under

fatigue stresses. As a rough guide a light alloy casting should weigh at least half the cast iron article it replaces, and any further reduction in weight is accompanied by risk of failure. These figures are based on experience, the light alloy casting having a suitable section for its purpose.

Aircraft Timber. (L. J. Markwardt, N.A.C.A. Rept. No. 354, January, 1931, 33 pp.) (10.4/21091 U.S.A.)

Two hundred and eighteen hard woods and 48 soft woods are tabulated with specific gravity dried, bending and compressive strength, hardness, shock resistance, stiffness, average figure of merit, and comparative figure of merit. The relation between specific gravity and bending strength is plotted and free curves drawn through the points representing fairly the average value, the points lying in well defined belts. The same remark applies to modulus of rupture plotted against specific gravity. Other mechanical properties are discussed fully. It is concluded that the data put the selection of aircraft material on a reliable basis. Twenty-one references are given.

Polarisation Optical Stress Measurements of the Corners of Bent Rods. New Device by H. Cardinal. (Mat. Pruf., No. 9, 1931, p. 129.) (10.406/21092 Germany.)

Experiments on flint glass, free from initial tension, show that the maximum tension at the inner edge does not lie in the axis of symmetry but on either side of it, increasing at the inner edge up to 84 per cent., according to the ratio of the bend to the depth; at the same time considerable radial tensions may exist.

Wind Tunnels

Tests with a Model Wind Channel. (M. Schilhansl, Z.F.M., Vol. XXII, No. 4, 28/2/31, pp. 107-117, 208th D.V.L. Report.) (11.1/21093 Germany.)

Details are given of the model channel, illustrated by five photographs and five diagrams. The powers required at different angular velocities of the impeller are plotted and a fair curve is drawn through the points, some of which show considerable scattering according to the day on which the observations were made. The distribution of velocity across the stream is exhibited by means of contour lines. By experimenting with different types of diffuser a saving of 10 per cent. in the power required was obtained. Seven references are given.

Design of Wind Tunnels. (E. F. Relf, Airc. Eng., Vol. III, No. 24, pp. 27-28.) (11.1/21094 Great Britain.)

The advantage of return flow wind tunnels in compactness and economy of power are discussed in view of the decision to instal a 24-foot tunnel of this type at the R.A.E. The disadvantages of increased turbulence in the stream are discussed. The advantage of an open jet for airscrew tests is also considered.

A Simple Six-Component Balance for the Kiffhauser Technical School Wind Channel. (E. v. Lossl, Z.F.M., Vol. XXI, No. 15, 18/8/30, pp. 393-396.) (11.16/21095 Germany.)

A diagram and photograph of the linkage are given. The forces in the linkage arms are transmitted through membranes to six manometer gauges, which may be calibrated to give readings in suitable units. Lift and resistance are simple sums and differences of the readings. The cross force involves a non-dimensional factor. The component couples are sums and differences of the readings multiplied by fixed lengths.

Airships

Metal Airship Construction. (W. Bleistein, Z.F.M., Vol. XXI, No. 24, 29/12/30, pp. 626-630.) (12.1/21096 Germany.)

A descriptive account is given of the methods of construction of metal airships and is illustrated by photographs and sketches.

Metal-Clad Airships. (U.S. Air Services, Vol. XVI, No. 2, February, 1931, p. 32.) (12.1/21097 U.S.A.)

Some technical details are given of a proposed metal-clad airship for the United States army, which will be slightly larger than the Graf Zeppelin, and will cost $4,500,000 to construct.

Airships. (U.S. Air Services, Vol. XVI, No. 2, February, 1931, p. 57.) (12.3/21098 U.S.A.)

Some account is given of progress on the Akron airships and power plant. Trial flights are expected by the summer of 1931.

Commercial Airship Progress. (S.A.E., Vol. XXVIII, No. 1, January, 1931, pp. 5-7.) (12.3/21099 U.S.A.)

The National Advisory Committee for Aeronautics (U.S.A.) recommends that lines be established forming a United States airship merchant service. Dr. Karl Arnstein, formerly chief engineer to the Zeppelin Co., discusses new lines of airship development.

The latest type of hull construction has main frames of triangular section and flexible bulkheads between individual gas cells to reduce stresses if one of the gas cells becomes deflated.

Cotton cloth covered with gold beater's skin makes satisfactory gas bags, but the skins are expensive and difficult to manufacture. Research has developed a rubberised fabric cell and a gelatine latex cell, both satisfactory. The rubberised cells are heavy, but are inexpensive and stand rough handling. The gelatine latex cells have characteristics similar to those of gold beater's skin, but are less expensive.

Wireless

Utilisation of Photo-Electric Cells with Glass Cover for Investigations on Radiation of Very Short Waves. (J. and J. F. Thovert, C.R., Vol. CXCI, No. 22, 1/12/30, pp. 1058-1059.) (13.3/21100 France.)

The photo-electric cell is rendered sensitive to the short waves by treating the glass surface of the cover with a thin layer of a substance which will fluoresce under the action of the short wave, *e.g.*, a thin layer of vaseline.

Application of Oscillogram to Transient Phenomena. (H. M. Turner, Proc. Inst. Rad. Eng., Vol. XIX, No. 2, February, 1931, pp. 269-281.) (13.2/21101 U.S.A.)

In recording transient phenomena by oscillogram the movement of the spot of light once along the path is insufficient to form an image on the retina. In the present apparatus the transient phenomenon is repeated periodically, and by suitable mechanical adjustments which are fully described the time-intensity curves, due to successive transients are superposed.

A number of diagrams are reproduced and illustrate the important information obtainable by this method.

Graphical Determination of Electric Field near Antennæ. (J. S. Petrie, J.I.E.E., Vol. LXIX, No. 410, February, 1931, pp. 290-298.) (13.31/21102 Great Britain).

From Author's Summary.—The mathematical calculation of the electric field in the immediate neighbourhood of a transmitting aerial is somewhat laborious, and the paper describes a graphical method by means of which calculations may be made for any desired arrangements of a transmitting aerial.

Investigations on Behaviour of Quartz Controlled Transmitters. (P. v. Handel, L.F.F., Vol. VIII, No. 5, 18/10/31, pp. 121-140.) (13.31/21103 Germany.)

Various forms of oscillation of the Piezo electric circuit are investigated. The magnitude of the grid current has great influence on the oscillation and successful working of the circuit. Special valves using very small grid current are required.

Impedence Correction of Wave Filters. (E. B. Payne, Bell Tele., B.531, December, 1930.) (13.5/21104 U.S.A.)

From Author's Summary.—The development of appropriate filter terminating sections has passed through a number of stages. The earliest filters gave reflection coefficients as great as 50 to 60 per cent. in the useful transmission band. The invention of " *m*-derived " and " *x*-terminated " filters, plus a number of more or less empirical schemes, made it possible to obtain reflection coefficients ranging from 10 to 15 per cent. in the useful band. Recent progress has resulted chiefly from the development of a series of sections, the simplest of which is equivalent to the *m*-derived type, while the others, of progressively increasing complexity, give progressively better approximations to the ideal characteristic. The use of the more complicated sections has made it possible to reduce filter reflection coefficients to the order of 2 per cent. or even less. At present the chief limitation appears to be the difficulty of manufacturing filters with sufficient precision to allow the theoretical characteristics to be realised. The paper is illustrated by figures showing the various stages of this progress as they are exemplified in actual designs.

Method of Impedence Correction. (H. W. Bode, Bell Tele., B.552, December, 1930, 42 pp.) (13.5/21105 U.S.A.)

A theoretical treatment is given of some recently developed wave filter terminating sections whose application is discussed in the accompanying paper on " Impedence Correction of Wave Filters." The sections consist primarily of non-recurrent ladder networks which operate, over the transmission bands of the associated filters, as transformers whose ratio varies with frequency. The transformation ratio of the network is specified, as a function of frequency, by a power series containing a limited number of terms and the design procedure therefore depends upon the construction of power series approximations to the ratio between the resistance of the filter proper and the desired resistance. A separate network is added to secure control of the reactance component. An increased number of terms in the power series and therefore an improved approximation to the desired transformation ratio, can be obtained by increasing the number of branches in the network. The method thus leads to a series of sections of progressively increasing complexity and with progressively improving impedence characteristics. By an inversion of the analysis a second series of sections can also be obtained. The paper is chiefly devoted to a discussion of these two series of filter sections, but other possible applications of the method are also described briefly.

The Selenium Rectifier. (J. Noack, Z.V.D.I., Vol. LXXV, No. 2, 10/1/31, p. 48.) (13.5/21106 Germany.)

The rectifier is built up of elements in series, each element consisting of a layer of metallic selenium welded to a copper plate and covered with a thin foil of copper, and is capable of dealing with about 24 volts. The back current is stated to be less than 1/10th of one per cent. of the transmitted current. Advantages are claimed over copper oxide rectifier.

Beam Arrays and Transmission Lines. (T. Walmsley, J.I.E.E., Vol. LXIX, No. 410, February, 1931, pp. 299-323.) (13.6/21107 Great Britain.)

Seven types of array are shown diagrammatically, and curves of directional intensity are given in certain cases. The question of losses in transmission lines is discussed, and an arrangement for reducing losses in open transmission lines leads to the conclusion that these losses may be reduced to a figure which competes with the concentric metallic tube transmission usually regarded as essential. Sixteen references are given.

The Present Position of Television (F. Schröter and H. Lux, Z.V.D.I., Vol. LXXV, No. 8, 21/3/31, pp. 237-239.) (13.7/21108 Germany.)

Attempts are being made to reduce the wave band to reasonable width by concentrating on the light portions of the picture for transmission, and by causing the light spots at the receiving end to remain longer on the brighter areas, which show more detail. The difficulties are considerable.

Acoustics

Propagation of Sound Waves in a Long Cylindrical Tube. (Th. Vautier, Ann. d. Phys., Vol. XIV, Nov., 1930, pp. 263-625.) (15.2/21109 France.)

The experiments were carried out in a nearly straight iron pipe 3 feet dia. and one mile long, laid at Lyons. The sounds were produced by firing small charges and the passage of the sound wave was recorded by interference fringes.

The speed of propagation and the type of wave front are closely dependent, and show satisfactory agreement with the theoretical conclusions of Hugoniot.

Accuracy of Measurements with Behm Air Height Ranging Device at Low Altitudes. (E. Schreiber, Z.F.M., Vol. XXII, No. 3, 14/2/31, pp. 77-79.) (15.25/21110 Germany.)

The source of sound for these experiments was a special pistol constructed by the Haenel-Suhl munition works. The experiments were carried out for heights between 4 and 18 metres, with a mean error of ± 1.3 metres. Between 19 and 100 metres an error of ± 3.5 metres had been determined previously on another instrument.

Aircraft Sound Locator; Acoustical Properties of Some Sound Collectors. (J. Obata and Y. Yosida, Aer. Res. Inst., Tokyo Imp. University Rept., No. 62, July, 1930.) (15.25/21111 Japan.)

Four types of sound collectors were used, two parabolic reflectors and two horns. Dimensioned sketches of the latter are given. Technical details are given of the sources of sound and the sound receiver, with sketches and diagrams of connections of the microphone circuits. The directional intensity is plotted on polar diagrams, and shows a fairly definite maximum in certain cases but a poorly defined maximum in others.

In the case of the horns there may be as many as seven maxima, of which the greatest is not necessarily in the direction of the sound source. Photographs are given of the various installations.

Analysis of Sounds Emitted by Aircraft. (J. Obata and Y. Yosida, Aer. Res. Inst., Tokyo Imp. University Rept., No. 59, March, 1930.) (15.3/21112 Japan.)

The apparatus consisted of a combined microphone seven-stage amplifier and oscillograph, of which a diagram of connections is given. Oscillograms are reproduced and a Fourier analysis is given of the principal frequencies. The sounds are so complex that it is not always possible to interpret the oscillograms, but an attempt is made to analyse the large mass of records reproduced. The results include the recognition of ground echo and fluctuation of intensity due to the wind.

Experiments were carried out with an airship, Benz engine, 130 h.p.; a bomber, Napier Lyon, 450 h.p.; a chaser, Hispano-Suiza, 300 h.p.; and a reconnaissance machine, Hispano-Suiza, 300 h.p.

Survey of Room Noise in Telephone Locations. (W. J. Williams and R. G. McCurdy, Bell Tele. Lab., B.526.) (15.38/21113 U.S.A.)

The noise meter described with illustrations, is designed on the principle of weighting the frequencies to stimulate the sensitivity of the ear so as to avoid the more elaborate apparatus required to analyse a number of narrow frequency bands. The accuracy of the instrument was compared with other methods and shows discrepancies of less than half a decibel over the entire range of observation. Four examples of measurements are given graphically.

Miscellaneous

Parachute Cloth, Physical Characteristics. (Air Corps Information Circular, Vol. VII, No. 651, 23/6/30, 11 pp.) (16.2/21114 U.S.A.)

A description is given of the test apparatus used and the method of procedure. Figures of tensile strength along warp and filling and Mullen burst values are tabulated. The results are also given graphically.

Photographs are given of pendulum impact tester, porosity meter, and Scott textile tester.

Italian Ascanio Helicopter. (Flugsport, Vol. XXIII, No. 5, 4/3/31, p. 78.) (17/21115 Germany.)

The lifting airscrews of the Ascanio helicopter are driven direct by a 94 h.p. Fiat engine. The blade tips are fitted with small elevator planes automatically varying the incidence. The inclination to the vertical is produced by subsidiary airscrews operated by the main engine. The following flights are recorded:—distance 1,000 metres in 5 min. 12½ secs., climb 16½ metres in 1 min. 40 secs.; time of longest flight 8 min. 45 secs. Hovering flight was maintained for several minutes in a balloon shed in spite of the disturbance of the air.

The Rotor Aeroplane. (Flugsport, Vol. XXIII, No. 5, 4/3/31, p. 79.) (17.1/21116 Germany.)

Experiments have been carried out in U.S.A. with a float seaplane fitted with rotor wing 2½ ft. in diameter, driven by a 90 h.p. engine. A three-bladed airscrew is driven by an independent engine.

It is stated that the seaplane left the water, but was subsequently wrecked.

Jet Propulsion. (E. G. Richardson, J.R.Aer.Soc., Vol. XXXV, No. 241, January, 1931, pp. 29-36.) (17.2/21117 Great Britain.)

The chemical and mechanical elements of the problem are treated somewhat discursively. From the main results it appears that it is just within the limits

of technical possibility to project a rocket with sufficient velocity to escape the earth's gravitational influence. It would, however, continue to move round the sun unless directed towards the moon, in which case it might end its career on the moon's surface. For starting purposes the efficiency of rocket propulsion is low in comparison with various forms of catapult. *A fortiori* it is unsuitable for ordinary flight.

The Future of the Rocket. (D. Lasser, Sc. Am., Vol. CXLIV, No. 3, March, 1931, pp. 164-166.) (17.2/21118 U.S.A.)

Drawings are reproduced from the U,S.A. patent specification of Prof. Goddard's duplex rocket. Reference is made to Scherschevsky's and Esnault-Pelterie's papers on the possibility of rocket flight.

The only practical application appears to be the exploration of the upper atmosphere to heights of the order of a hundred miles by recording instruments returning to the earth by parachute.

Ornithopter Problem; "Flapping Wing" Flight of Birds. (Capt. Guillaume, Rev. f. Aer., No. 16, November, 1930, 1340-1363.) (17.3/21119 France.)

Research on flapping flight is reviewed. Even if mechanical difficulties could be overcome an ornithopter would be less efficient aerodynamically than existing aeroplanes.

Catches for Holding Gliders. (Aero. Rev., No. 2, 15/1/31, pp. 16-17.) (17.4/21120 Switzerland.)

The glider is held on the ground by a cable and the starting rubber bands are stretched by assistants to the requisite tension. The pilot then releases a catch and the glider is launced. The method has become standardized in Switzerland.

American Naval Flying. (Lieut. L. D. Webb, U.S. Air Services, Vol. XVI, No. 2, February, 1931, pp. 19-24.) (18.01/21121 U.S.A.)

An account is given of the manœuvres of fleet carriers and aircraft. A photograph is given of the Lexington, which maintained over 32 knots for 24 hours, developing over 210,000 h.p. Over ten thousand launches from catapults have been carried out in ten years without a fatality; and eighteen thousand landings on carrier decks have been made in 2½ years without serious injury.

Measurement of Height of Clouds. (Z.F.M., Vol. XXI, No. 21, 14/11/30, p. 571.) (19.1/21122 Germany.)

The height of the cloud is measured by the angle of elevation of beam from a searchlight placed at a known distance from the observer. Types of searchlight for this work are described. The firm of Pintsch manufacture a projector of three million heffner candles, the image thrown on a cloud being visible in moonlight.

Ice Formation on Aircraft in Flight. (O. Heitmanek, Aer. Rev., Vol. VI, No. 6, 15/3/31, pp. 72-75.) (19.15/21123 Switzerland.)

A description is given of loss of controllability during a winter flight in Switzerland, ending in a spin which was attributed to ice formation, although on landing no ice remained. Quotations are given from American work, with illustrations of typical ice formation on struts and round stream-lined wires.

Matters Affecting Pilots

Cinematograph Study of Dilation of the Heart by Deficiency of Oxygen. (H. Strugold, Z.F.M., Vol. XXI, No. 24, 29/12/30, pp. 645-648.) (19.2/21124 Germany.)

The physiological effects of lack of oxygen are discussed and the heart of a hound under narcotics was exposed and cinematographed to exhibit the dilation. Records of the results are given in tables and charts and a strip of the film is reproduced. Fifteen references are given.

Aerial Acrobatics. (R. Greim, Flugsport, Vol. XXIII, No. 6, 18/3/31, pp. 104-116.) (19.29/21125 Germany.)

Various manœuvres are described with the concomitant movements of the controls. Many of the manœuvres cause physical discomfort and may lead to temporary unconsciousness, especially the outside loop. Details are given of the examination undergone by a pilot before giving paid public exhibitions.

Variation of Power with Height. (W. G. Jennings, Airc. Eng., Vol. III, No. 25, March, 1931, pp. 55-56.) (19.3/21126 Great Britain.)

In the first part of the paper the usual empirical equations are given showing brake horse-power as a function of air pressure and density with fractional indices.

In the second part the indicated horse-power is taken as the fundamental physical variable. The losses are divided into approximately constant losses and losses varying with the density. Numerous factors of indeterminate importance require further investigation, but the basis of a truly physical theory is formulated. (Cf. A. R. Low, Aeronautics, 1920, p. 223). Reference is made to supercharging and to the need for further research.

High Altitude Aeroplane. (Flugsport, Vol. XXII, No. 5, 4/3/31, p. 80.) (19.3/21127 Germany.)

A high altitude aircraft ordered by the French Air Ministry from Messrs. Farman, has a 400 h.p. engine, and a variable pitch metal airscrew. Three supercharge ratios come into operation successively at 6,000, 10,000 and 15,000 metres. The cylindrical aluminium cabin is kept at ground level pressure by the supercharger. A designed ceiling of 20,000 metres is mentioned.

Seat and Safety Belt in an Aircraft. (E. Gilbert, Z.F.M., Vol. XXI, No. 24, 29/12/30, pp. 648-652.) (19.37/21128 Germany.)

The correct methods of setting and applying the safety belts are considered in their medical aspects and illustrated by four X-ray photographs.

Aerodynamics and Hydrodynamics

Stability of Motion of Rectilinear Vortices in Ring Formation. (T. H. Havelock, Phil. Mag., Vol. XI, No. 70, February, 1931, pp. 617-633.) (22.1/21129 Great Britain.)

The case of a single ring of vortices is examined and reference is made to Kelvin's solution for three vortices, to J. J. Thomson's result that the configuration is stable for six or fewer vortices, and to the analogy with Mayer's experiments on stability with floating magnets. The author applies methods analogous to those of Lamb and von Kármán and confirms J. J. Thomson's result for a single ring. A solution is also obtained for a double ring with alternate arrangements, and it is found that there is stability excepting for a particular limiting case.

By increasing the radius of the double ring indefinitely von Kármán's solution for the stability of a linear double row of vortices is obtained as a limiting case.

Stability of Kármán Vortex Street in a Channel of Finite Breadth. (Susumu Tomotika, Aer. Res. Inst., Tokyo Imp. University Repts., No. 48 (August, 1929), and No. 55 (January, 1930.) (22.1/21130 Japan).

The complex velocity potential due to the double row of vortices and their images is expressed by a doubly periodic function corresponding to the double periodicity of the vortices and their images in the whole plane. The form selected is the logarithm of quotients of sigma functions. On differentiating, the conjugate of the complex velocity is obtained in terms of sums and differences of zeta functions of distances from the poles. Using the addition theorem for the zeta function the real and imaginary parts are separated, and the components of the velocity are obtained in terms of zeta and Weirstrass functions and their first derivatives. To examine the stability, small displacements are imposed on the vortices, and the conditions for the increase or decrease of the displacements are examined. These conditions are expressed in terms of Weirstrass functions and computed numerically and tabulated. Certain ranges of stability are found for ratios of breadth of street to breadth of channel lying between 5/16 and $\frac{3}{8}$ for the von Kármán type of disturbance. For a more general type of disturbance it appears that there are at most two essentially stable configurations. (Compare with Rosenhead's treatment of the problem. Abstract No. 11/11300 & 1).

Some Experiments on the Motion of Fluids. (T. Terada and K. Hatori, Aer. Res. Inst., Tokyo Imp. University Reports, No. 16, May, 1926, and 26, August, 1927.) (22.1/21131 Japan.)

Part I. Nineteen photographs are reproduced of motions of convection currents with a variety of boundary conditions. These are all of an irregular nature as compared with Benard's experimental work, in which great geometrical regularity was obtained.

Part II. Motions of fluids set up by rotation of discs, spheres and cylinders are considered. Seventy-eight photographs of fluid motion are given. Taylor's type of instability between rotating cylinders is reproduced, and the experiment is further modified by setting the cylinders eccentrically and by introducing obstructions between the cylinders. It is not clear what advantage is gained by thus complicating the phenomena under consideration, and in general the authors seem rather to lose sight of the desirability of isolating phenomena, for observation and solution,especially in so intractable a subject as viscous fluid motion.

The Possible Steady Motions of a Heavy Fluid. (H. Poncin, C.R., Vol. CXCII, No. 9, 2/3/31, pp. 543-546.) (22.1/21132 France.)

The methods of conformal representation are extended to represent steady flow along a two-dimensional channel with curved walls. A solution is given for a channel with decreasing section down stream in the form of an integral equation involving elliptic functions.

Resistance of a Cylinder in a Channel of Finite Breadth. (S. Tomotika, Aer. Res. Inst., Tokyo Imp. University Rept., No. 58, March, 1930.) (22.1/21133 Japan.)

The work of H. Villat and L. Rosenhead (see 9/10477 & 8, 11/11300 and 1, 15/13115, 16/13520) is discussed in somewhat different but equivalent form. The leading results are identical with Rosenhead's and where the form is very different the equivalence is formally demonstrated. Villat's apparent paradox that

Kármán's formula is not approached in the limit when the walls of the channel are removed to an infinite distance is resolved and v. Kármán's result is obtained as a limiting case. Sigma functions, zeta functions and Weirstrass functions are used throughout.

Measurement of Flow through Orifices. (K. Jaroschek, T.M.T., Vol. I, No. 12, December, 1930, pp. 423-428.) (22.2/21134 Germany.)

Following Witter's experiments with orifices in tubes the paper deals with coefficients of free discharge from a tank. The coefficient increases with Reynolds number and with the height of the free surface above the orifice. V.D.I. and I.G. nozzles (1930), with coefficients previously determined, were inserted in tubes; expressions obtained for the effect of the tube diameter, and, by extrapolation, for free discharge. The calculated results were 2 per cent. lower than experiment. The flow coefficient of a sharp edged orifice decreases with increasing Reynolds number.

A bibliography is given.

Resistance in Curved Pipes. (H. Richter, Z.V.D.I., Vol. LXXIV, No. 22, 27/12/30, pp. 1757-1758.) (22.5/21135 Germany.)

Experimental values are plotted graphically against Reynolds number and compared graphically with the results for straight pipes. The losses are in every case higher both in the laminar range and in the turbulent range of flow, but the difference is less in the latter case than in the former. For a complete representation the ratio of the curvature to the radius of the tube requires to be taken into account.

A General Equation for Heat Transmission of Fluid Flow in Pipes. (T. Bosch, Z.V.D.I., Vol. LXXV, No. 2, 10/1/31, pp. 40-42.) (22.2/21136 Germany.)

Prandtl has given an expression for the heat transfer, depending among other factors on the Reynolds number and the ratio of mean velocity to velocity at the boundary of the laminar flow estimated from other experiments. By substituting this ratio in Prandtl's expression the author has computed tables for the heat transfer for various sizes of tubes and rates of flow of water.

Temperature and Velocity Field near a Warm Vertical Plate. (E. Schmidt and W. Beckmann, Z.V.D.I., Vol. LXXV, No. 8, 21/2/31, p. 227.) (22.1/21137 Germany.)

The formula is based on Pohlhausen's investigation. Experimental values of the temperature and velocity fields are plotted graphically.

Loss of Pressure in Smooth Bent Tubes. (H. Richter, Z.V.D.I., Vol. LIV, No. 52, 27/1/30, p. 1757-1758.) (22.2/21138 Germany.)

In a straight tube the change from laminar to turbulent flow produces a region of instability in the resistance coefficient; in a curved tube the change progresses uniformly from laminar to turbulent flow. For low Reynolds numbers there is considerable differences in the resistance coefficients of bent and straight tubes. At high values of R the difference becomes small.

Experimental Hydrodynamical Study of Currents of Air by Methods of Optical Interference. (R. Tremblot, C.R., Vol. XCII, No. 8, 23/2/31, pp. 480-482.) (22.4/21139 France.)

Reference is made to Prandtl's work in 1907 on measurement of velocities above that of sound. In the present paper Cranz's method of photographing waves of condensation and rarefaction in the air round projectiles is employed

and is applicable to speeds below that of sound. The stream of air passes through a channel with curved surfaces and bounded at the sides by flat glass plate. The section parallel to the plates first converges and then diverges. Photographs are taken by electric spark, and a numerical example indicates the method of calculating intensity from the interference displacements. A sketch illustrates the nature of the photographs obtained, and the densities are plotted against axial position in the channel with an error stated to be 1 per cent. Certain interesting concomitant phenomena are mentioned.

Distribution of Pressure Round a Sphere in an Air Stream. (O. Krell, Z.F.M., Vol. XXII, No. 4, 28/2/31, pp. 97-105.) (22.4/21140 Germany.)

Photographs and dimensioned diagrams give the details of the mounting of a sphere of 8 cm. diameter in the wind channel. Nine polar diagrams show the distribution of pressure graphically. A projecting ring is fitted round a small circle, corresponding to latitude 43°, and is of rectangular section 2 mm. high by 1 mm. wide. Photographs exhibit the region of turbulence behind the sphere with and without the ring.

Six photographs are also given of two-dimensional flow of water past a cylinder with parallel rods lying along generators at $\pm 67\frac{1}{2}°$ and $\pm 43°$ from the plane of symmetry with respect to the current.

Ship Wave Resistance. (W. C. S. Wigley, N.E.C. Inst. Eng. Trans., Vol. XLVII, Part 4, March, 1931, pp. 153-180.) (22.1/21141 Great Britain.)

A mathematical theory of wave formation is worked out in terms of Bessel functions, and numerical values are plotted graphically. Substantial agreement between the theory and measured results is claimed for two very different cases.

Miscellaneous—Unclassified

Tables for Use in Astronomical Aero Navigation. (P. F. Everitt, J.R.Aer.Soc., Vol. XXXV, No. 242, February, 1931, pp. 167-172.) (0/21142 Great Britain.)

A list of useful tables is given, and their application is illustrated by a number of worked out examples.

American Guggenheim Safety Competition. (W. Pleines, Z.F.M., Vol. XXI, No. 15, 18/8/30, pp. 381-391.) (0/21143 Germany.)

An account of the technical measurements and decisions is given, which follows closely the official report.

Air Safety Services (R. Benkendorff, Z.F.M., Vol. XXI, No. 24, 29/12/30, pp. 623-626.) (0/21144 Germany.)

The summarised lecture discusses the problems of wireless signals, weather reports, and supply of light beacons for night flying. At present eighteen German air ports have wireless apparatus installed, and twenty-four are inter-connected by 3,500 km. of cable. For the weather service five stations are installed at Berlin, Hamburg, Darmstadt, Munich, Konigsberg. By means of regular daily ascents to 6 km. atmospheric conditions are given up to this height. Weather prediction along a selected route is considered more valuable than synoptic charts for a fixed time over a wide area.

Summarised Report of the 19th Meeting of W.G.L., 11/9/31. (Z.F.M., Vol. XXI, No. 24, 29/12/30, p. 621.) (0/21145 Germany.)

In addition to administrative reports reference is made to the work of the committees on gliding, navigation, medical questions, air law, inventions, units and symbols, technical terms, etc.

American Naval Aviation. (Rear-Admiral W. H. Moffett, U.S. Air Services, Vol. XVI, No. 2, February, 1931, pp. 43-45.) (o/21146 U.S.A.)

The relation of aviation to fleet work is the subject of a statement by Admiral Moffett, Chief of the Bureau of Aeronautics, covering every aspect of naval air operations.

Airships. (U.S. Air Services, Vol. XVI, No. 2, February, 1931, p. 32.) (o/21147 U.S.A.)

It is sought to make airships eligible for United States mail subsidies.

Civil Aviation: Subsidies. (J. P. van Zandt, U.S. Air Services, Vol. XVI, No. 2, February, 1931, pp. 15-18.) (o/21148 U.S.A.)

An international comparison is made from which it appears that the United States paid the highest effective subsidy of any nation. Technical superiority is claimed in speed, comfort, and freedom from noise.

Value of Scientific Research. (Aviation, Vol. XXX, No. 1, January, 1931, pp 3-4.) (o/21149 U.S.A.)

The value of scientific research is defended against certain criticisms, with examples of general research work which has improved design as a whole, and particular applications which have improved individual flying qualities.

Airport Construction. Gliding. (Aviation, Vol. XXX, No. 1, January, 1931, pp. 31-33.) (o/21150 U.S.A.)

Statistical, financial and some technical data are given for air port construction in the United States and Canada. The position of gliding is discussed. At the Elmira meeting a height of 2,409 feet was reached, and a duration flight of seven hours forty-three minutes was carried out.

Airscrew-Driven Rail Coach. (Z.F.M., Vol. XXI, No. 23, 15/12/30, pp. 615-616.) (o/21152 Germany.)

A streamlined coach of 19 tons tare attained a speed of 110 miles an hour with a two-bladed airscrew at the rear driven by a 12 cylinder B.M.W. Mk. VI engine. At 90 m.p.h. in still air 200 engine h.p. is absorbed. Acceleration to 60 m.p.h. from rest takes one minute.

Theory of Deposition of Dust from a Stream of Air; with Application to Dust Filters. (F. Albrecht, Phys. Zeit., Vol. XXXII, No. 1, 1/1/31, pp. 48-56.) (o/21153 Germany.)

Assuming potential flow, the path of a dust particle moving in the neighbourhood of a cylinder is calculated by the step by step method. The results obtained are correlated with the form of deposits of hoar-frosts obtained under certain conditions. References are given to work by von Kármán and Albrecht with applications to meteorology.

Removing Carbon Deposits from Cylinders such as those of Internal Combustion Engines. (T. Midgley, jun., and C. A. Hochwalt; to General Motors Research Corp., U.S.1, 1,786,860, December 30. Chem. Absts., Vol. XXV, No. 4, February, 1931, p. 802.) (o/21154 U.S.A.)

After heating the metal to 65°, a mixture of high and low b.p. organic compounds is applied to the deposit.

A specified mixture is aniline 25 per cent., alcohol 25 per cent., benzine 25 per cent., naphthalene 25 per cent.

(W. G. Lovell and T. A. Boyd; to General Motors Research Corp., U.S. 1,787,789, January 6. (Ref. as above.)

The metal is heated and the coated parts are treated with an aliphatic amine boiling above 64°, such as hydroxyethylamine, to facilitate removal of the deposit. Alcohol, C_6H_6, aniline, furfural, etc., may also be used.

SOME NOTES ON FLYING BOATS AND SEAPLANES

BY

J. H. LOWER, A.F.R.Ae.S.

(Lecture read before the Halton Branch, September, 1930.)

(Abridged.)

The terms " Flying-boat " and " Seaplane " convey to our minds two distinct types of marine aircraft, which have many points in common and yet many points not in common, and together they cover such a vast amount of subject matter, that it is only possible to deal with a limited number of aspects in this paper.

Description of Machines

The Short " Cockle " was fitted with two 696 cc. Blackburn engines, and constructed entirely of metal with the exception of the fabric covering on the planes. This flying boat was the first all-metal type produced in this country, and was the first two-engined light plane in the world. It belonged to the monoplane category, and the engines were mounted some distance behind the leading edge, with extension shafts to the propellers.

The hull, although vastly different from present day lines, was of the two step type, the steps being formed by additional wedge-shaped pieces secured to the main portion, which was constructed of transverse frames with intercostal stiffeners.

Following soon afterwards, the old type of F.5. flying-boat was used for a noteworthy experiment. For a considerable time Messrs. Short Bros. had been firmly convinced that future flying boats must be of the all-metal type, for many reasons, and that the metal should chiefly be duralumin, but unfortunately it proved exceedingly difficult to convince, to anything like the same degree, the Air Ministry.

The firm's initiative in producing the " Cockle " was rewarded, for besides purchasing the machine, the Air Ministry requested that a metal hull be constructed and fitted to a standard F.5. superstructure.

This was the great stepping stone in the history of British flying boats, for besides being of much lighter weight, the absence of soakage of water after a period of service, made an appreciable difference to performance. The hull was of the two-step type, and proved to be exceedingly robust. The bottom sheeting was shaped to a number of transverse corrugations, these having, as it was then thought, two distinct functions to perform; firstly, to strengthen the bottom of the hull, and secondly, to decrease the size of the waves thrown off during the run to take-off, and consequently cause less resistance.

The second characteristic was true to a certain degree, but research and experiments during recent years have shown that hulls are more efficient without corrugations, and following this, methods of construction have advanced, whereby they are not necessary from strength considerations.

However, the F.5. experiment was beneficial from many points of view, and had a tremendous bearing upon machines which were to follow.

One such machine is the " Singapore," which after considerable service in the Air Force, was loaned to Sir Alan Cobham for his flight of 23,000 miles round

Africa. That flight indicated the possibilities of the all-metal British Flying Boat, which even yet have not been fully realised. Upon its return to England, the "Singapore" was flown to Rochester for alterations as a result of the experience gained.

The hull (Fig. 1) was cut completely in two just forward of the front spar frame, and by some ingenious scheming, a new bay 1ft. 6in. long was let in, making the forebody this amount longer. In addition the whole of the bottom sheeting to suit the required new shape, and new sheeting fixed. The work was most successful, for besides showing the immense possibilities for repairs to metal constructed machines, the modifications were afterwards found to be justified, since a pronounced increase in efficiency was obtained.

The "Calcutta" is one of the latest types of flying-boats, and has proved efficient as well as seaworthy. This type form a fleet operating on the Mediterranean section of the England to India service. Many noteworthy points could

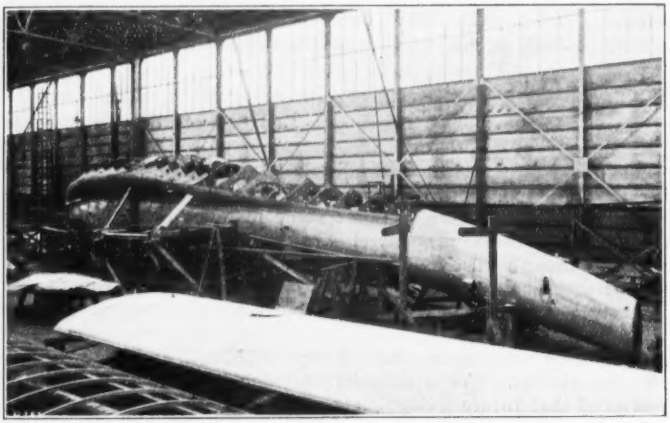


FIG. 1.

be referred to regarding the "Calcutta," one in particular being the "fairing" of the hull shape just aft of the rear step, a characteristic which was found to be advantageous on the water, as well as aerodynamically, after exhaustive tank tests, resulting in the tail of the hull being clear of water at all speeds, thus reducing the resistance considerably.

The machine, fitted with three "Jupiter" engines developing a total of 1,550 h.p. and weighing, when fully loaded, 22,000lbs., has a range of about 600 miles.

The internal arrangement, Fig. 2, is worth noting. The interior of the hull is laid out so as to accommodate fifteen passengers comfortably. In addition a wireless compartment is fitted between the pilot's cockpit and the cabin, while aft is a buffet with necessary equipment for a steward, lavatory, and space for luggage and mails. Any light luggage may be placed in racks provided in the cabin in a similar manner as is customary in railway carriages. The cabin seats are strong, although remarkably light in weight, being constructed of duralumin tubing and suitably upholstered. Air cushions are fixed to the seat and back rest, and are so made as to be quickly detachable to form a life-saving jacket in case of emergency.

Twin float seaplanes had usually developed as an afterthought to landplanes, but recently it has been shown that the former are capable of even exceeding the performance of the latter, and to such an extent that the tables might be reversed. Unquestionably the development of Schneider Trophy machines gave a great impetus to float design, as practically all modern floats are based upon the extensive research carried out with models of this type of aircraft. Messrs. Short Bros. in particular, when investigating the floats for the Crusader machine, Fig. 3, which went to Italy with the English team in 1927, began research on

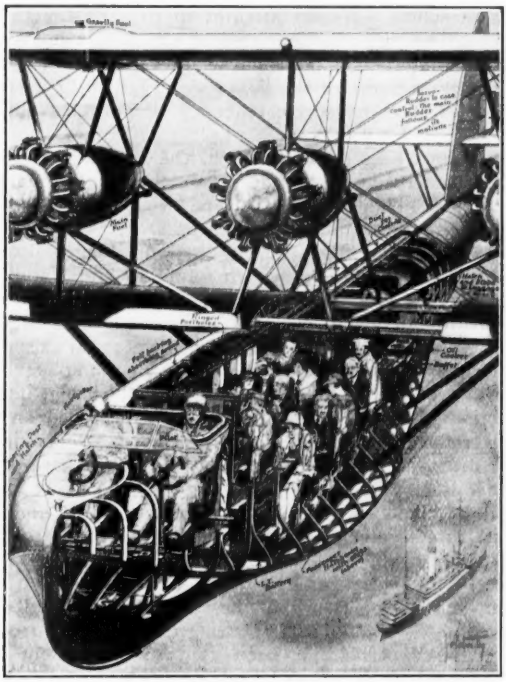


FIG. 2.

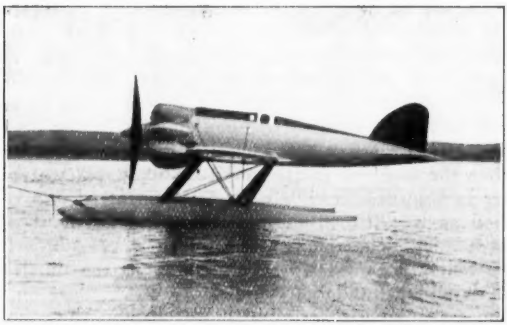


FIG. 3.

entirely new lines. As a basis for the tests, a perfectly streamlined model of circular cross section was constructed, and from this, after innumerable modifications extending over a period of several months, lines were produced which gave a float whose air drag and water performance were a considerable advance on anything which hitherto had been achieved and consequently the " Crusader " floats became a type upon which all succeeding designs of the firm were modelled.

The first seaplane ever constructed, merely consisted of a normal landplane, to the undercarriage of which were attached air bags. Afterwards, wooden pontoons were built which were an attempt to design something fulfilling the function of a float. They usually consisted of short twin floats with a tail float placed underneath the stern end of the fuselage, in order to give static longitudinal stability. The bottoms of the floats were flat, with a step well aft, and usually this type showed considerable tendency to porpoise during the take-off run.

The water resistance was generally high, the air drag considerable, and the weight of the floats excessive, with the result that the seaplane usually had a very poor performance. This square box type of float persisted for some years, and even to-day traces of the family are to be seen. German constructors improved slightly on the foregoing type, by making longer floats, whereby the tail float could be dispensed with, although retaining static stability, and having the forebody bottom flat but with a " Vee "-shaped section aft to minimise landing shocks. Although results were better, there was still considerable room for improvement, as the water and air resistances were still excessive.

The next marked improvement came with the complete " Vee " planing bottom, and also the round top shape to the floats which lent itself so favourably to metal construction. All modern floats are now modelled on these lines, but with considerable refinements in design whereby clean running, lower water resistance and air drag, and without tendency to porpoise, are produced.

The " Short-Mussel " was produced as a seaplane at a time when the privately-owned light plane was becoming a realised fact, and led the way for the light two and three-seater seaplanes which to-day are so numerous. This machine was built entirely of metal with the exception of the fabric wing covering, and, carrying pilot, passenger and usual luggage, had an all-up weight of 1,650lbs. A later version of this machine, after having had considerable use, has been converted into amphibian, the design of which introduced the single float type of seaplane that has not been used to any extent in this country, although widely adopted in the United States.

The central float, of normal construction, is mounted beneath the fuselage, while transverse stability on the water is obtained by smaller floats attached to the planes in a similar manner as is found on most flying boats. The land chassis portion is cradled in a trough cut into the float, and consists of two normal wheels with fork tubes, housing compression rubbers, which are secured to the main axle. This axle is supported by two bearing blocks fixed in the trough of the float, and is thereby acting as a cantilever in bending and torsion. A winding control mechanism operated by a handle in the cockpit, enables the axle to be rotated, hence placing the wheels upwards and forward to a position clear of water when the machine is used as a seaplane. A water rudder, operated by the rudder bar in the cockpit, it attached to the stern end of the main float, and is so designed as to perform the function of a tail skid when the machine is used as a landplane. The machine has been very successful, the landings on an aerodrome being declared by several pilots to be much softer than with a normal type of landplane undercarriage.

The single float seaplane is certainly more efficient that the twin float type, for despite the increase in weight due to the double undercarriage, the " Mussel "

as an amphibian, takes off from the water in slightly less time than when originally built as a twin float machine.

Several De Havilland " Moth " machines have been fitted with the " Mussel " type amphibian undercarriage by Messrs. Short Bros. and the same successful results have been obtained, and when the advantages of being able to alight on sea or land are considered, it is probable that in the near future developments in this direction will be seen.

Many other types of seaplanes could be mentioned, most of them having been merely converted from landplanes, but an exception is the case of a very recent machine, the Short " Valetta," a seaplane weighing 22,500lbs. This machine was primarily designed as a seaplane, with a view to being convertible to a landplane, and, having seating accommodation similar to a " Calcutta " flying-boat, should serve a useful purpose in dteermining the relative merits of flying-boat versus seaplane. The fuselage is built on similar principles to a flying boat hull, of monocoque form, with an entire absence of internal bracing. Accommodation for two pilots is immediately behind the centre engine, in a large cockpit fitted with a sliding roof. The glass sides extending from the windscreen are arranged to slide at will, thus providing good view and ventilation for the pilots. Immediately aft of the pilot's cockpit is the forward luggage compartment and wireless equipment. A sliding door at the aft end permits of access to the passengers' cabin, which is 17 feet long by 6 feet high, and 6 feet 2 inches wide, with ample room for 18 passengers seated three abreast.

The large windows at the sides of the cabin are capable of being opened, and by means of suitable lagging external noises are eliminated as much as possible. Special fans are also installed for ventilation. The seats are a similar type as were described for the " Calcutta," but while various improvements in upholstery, etc., have been incorporated, the use of the air cushions as life-saving jackets has been maintained. The main passengers' entrance is on the port side of the forward part of the cabin, leading from steps secured to the front strut on the float. These steps are housed inside the fairing, and a hinged cover totally encloses them when the machine is in flight. An emergency exit for the passengers is through a door aft of the cabin, on the starboard side, which door is primarily for taking aboard luggage, this being assisted by the use of a special hoisting gear. Lavatory accommodation is provided aft, the compartment being completely equipped with folding wash basin.

The wing span is 107 feet, and the floats just over 39 feet in length. With three " Jupiter " engines developing a total of 1,575 h.p. the top speed approximates to 135 m.p.h.

The Design of Hulls and Floats

The take-off characteristics of a flying boat or seaplane are very different from those in the case of a normal landplane. A pilot taking off from an aerodrome lifts the tail of his machine as soon as possible, but with marine aircraft, the pilot has practically no longitudinal control until a speed is reached equivalent to about 60 per cent. of that at which the machine is air-borne. All hulls and floats have individual characteristics peculiar to themselves, and before a machine is built it is advisable to determine as much information as possible regarding the proposed shape of the hull or floats, as the case may be.

Such information is obtained during tests carried out on a tank, and since the design of hulls and floats is largely dependent upon the results of tank tests, it is thought advisable to give as briefly as possible, some idea as to how these tests are conducted.

The tank at Messrs. Short Bros.' works, built of reinforced concrete, is 300 feet long, 6 feet wide, and contains water to a depth of 3 feet 6 inches. Rails,

laid along the top of the walls, enable an electrically-driven carriage to run along the entire length of tank, and upon this carriage is mounted the necessary apparatus. (Fig. 4).

Centrally over a rectangular hole in the floor of the carriage is fixed a framework; this accommodating the main sliding frame to which the model under test is attached. It should be stated that the model is accurately made of mahogany or some such suitable wood, to represent to scale the shape of the hull or floats proposed for the particular machine under consideration. To the model

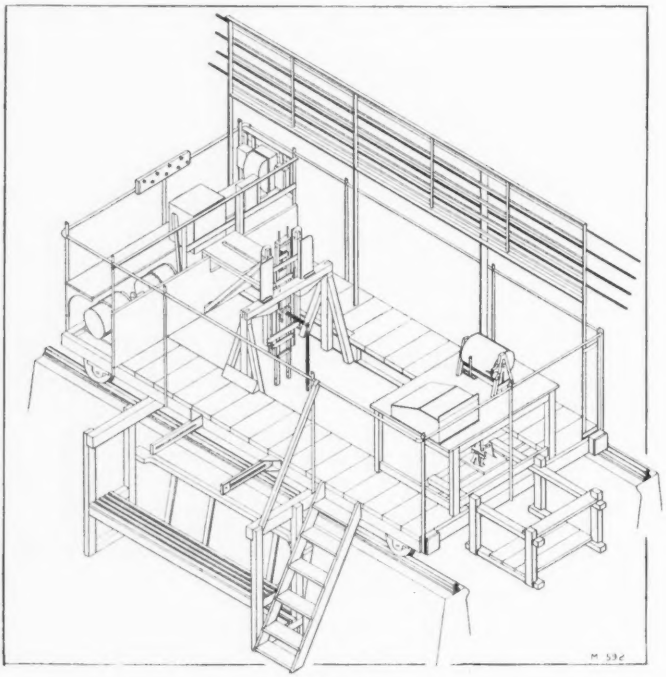


FIG. 4.

is fixed a framework which, by the addition of suitable lead weights, enables the model to be balanced about a transverse axis through a position corresponding to the centre of gravity of the complete full size machine.

The main sliding frame on the carriage, consists of a central swinging frame supported upon knife-edge pivot points between the sides of an outer frame mounted on ball bearings, which is free to slide in fixed guides. To the central frame is attached the model after having been balanced. By means of weights attached to one end of light wires over pulleys, the model is first of all enabled to float freely with a displacement equivalent to the all-up weight of the full size machine. From a point vertically above the representative centre of gravity position on the model, is attached a towing rod, which represents to scale the propeller thrust axis of the aircraft. This towing rod is of very light weight, although rigid, and at its other end is connected to one side of a lever arm extending from a calibrated torsion rod. The opposite side of the lever arm is used, through a magnification link system, to record the pull in the towing rod

when the model is being run, by means of a deflection registered on a revolving drum. This drum is geared to the front axle of the carriage, and as it revolves an electrically-controlled timing apparatus enables the speed of the carriage to be determined very accurately at the same time as the pull in the towing rod is being recorded.

A parallel link apparatus is used to record the angle of some fixed datum line on the model relative to the water level.

First of all, two main points are required to be known about the hull or floats during the run to take off, viz., the water resistance and the angle taken up by the datum line, and both of these quantities vary with speed. The water resistance is assumed to be wholly due to wave-formation, the results being predicted for full size from the model records, on the basis of Froude's Law of Similarity, that, for corresponding speeds, *i.e.*, in the ratio of the square root of the linear dimensions, the wave-making resistance is proportional to the cube of the linear dimensions. Hence, a model of scale 1/16th full size will have to be run at one quarter of the actual speed, while the recorded resistance will be multiplied by 16^3 to obtain the full size value. It will be clearly understood that such an assumption is justified, when it is stated that, combining results thus obtained with aerodynamic characteristics of the machine, the time for a large flying-boat or seaplane to take-off the water can be calculated to within about plus or minus one second.

The planes on the full size aircraft are attached at some fixed angle relative to the datum line, and consequently the running angle of the hull or floats has a bearing upon the lift obtained. The model is accurately balanced about an axis representing the full size centre of gravity position, and thus when under correct conditions of loading, will take up a position when running as would be expected in full size.

It is decided to commence the tests by running the model to correspond to a certain full size speed. The various weights on the sliding frames are adjusted so that the equivalent loading is applied, *i.e.*, the all-up weight of machine less the lift of the planes, the latter being calculated from the known characteristics of the wing section, assuming some angle for the datum line. If the assumption for angle is wrong, as found by the recorded value during the run, then a correction must be applied and the test repeated. This is carried out for a range of speeds, and the resistance and angle records then plotted graphically. (Fig. 5).

It will be seen that the resistance of a hull increases to a maximum, which is termed the " hump " value, then steadily decreases as the take-off speed is reached, and to be an efficient hull, this " hump " resistance must be as low as possible, and the decrease at higher speeds as rapid as possible. The curves shown are typical for a modern type of efficient hull, and but slight alterations to the shape would be necessary to give an increased " hump " value, and far from steady decreased resistance at higher speeds.

The attitude curve, showing the angle of the datum line at any speed is also interesting, since it will be seen that there is practically a steady increase during the run to take off, although usually just before the machine becomes air-borne the hull trims forward slightly.

The resistance curves for seaplane floats are similar to those for hulls, but the attitude, instead of steadily increasing, usually reaches a maximum value in the vicinity where the " hump " resistance occurs, and then decreases gradually until the take-off speed is reached, when the value is about three to four degrees less than the maximum.

The running angle of hulls and floats is important in the design of the machine, since the planes can then be fixed at such an angle of incidence that the lift is made use of efficiently, and also without allowing the stalling angle to be reached which would naturally have dangerous consequences.

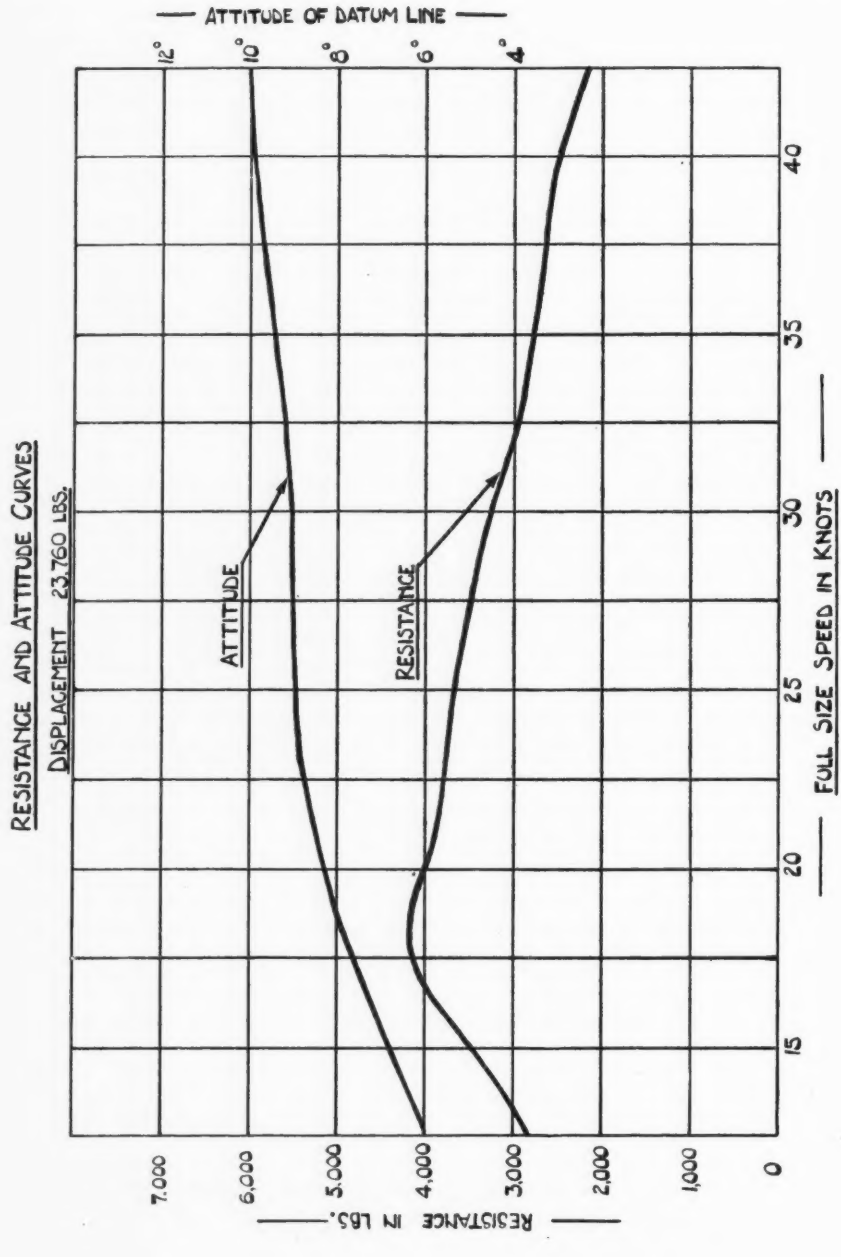

RESISTANCE AND ATTITUDE CURVES
DISPLACEMENT 23,760 LBS.
ATTITUDE OF DATUM LINE
12°
10°
8°
6°
4°
ATTITUDE
RESISTANCE
RESISTANCE IN LBS.
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
15
20
25
30
35
40
FULL SIZE SPEED IN KNOTS

FIG. 5.

Hence it can be seen that a flying boat, whose angle of incidence of the planes gradually increases with increase of speed, due to the characteristics of the hull just explained, will accelerate from rest and fly off the water without any appreciable elevator control. With a seaplane, however, where the angle decreases at higher speeds, the pilot has to trim the machine aft when the correct take-off speed is reached so that the necessary lift from the planes is obtained to allow the machine to become air-borne.

Thus, it is required to know the characteristics of floats at higher speeds when subject to moments which are applied by up or down loads on the tail plane. This is done by running the model at constant speed under correct conditions of loading, etc., but with various moments applied, and the apparatus is so designed that loads are applied at a position corresponding to the centre of pressure on the full size tail plane. For each moment applied, a new angle of trim is taken up by the floats, and a new value for the water resistance is obtained, and usually the resistance and moment values are plotted to a base of angle of trim, the resulting curves being termed " Cross-curves."

Such tests as these are carried out with models of flying boat hulls also, Fig. 6, the reason being seen from the following :—

The curves shown are typical cross-curves for a hull. The point of intersection between the moment curve and the base line, denotes the natural running angle, and it is seen that results are obtained with moments which trim the hull forward as well as aft. Now looking at the resistance curve, it is apparent that as the hull is trimmed forward to a certain angle, the resistance value decreases, notwithstanding that less lift has been obtained from the plane due to the smaller angle of incidence and which, of course, has to be taken into account during the tests.

Thus, if during the run to take off the pilot trims the machine forward slightly after the " hump " speed has been reached, the resistance is decreased, and quicker acceleration will result, with less time taken to become air-borne, and when the take-off speed is approached it is only necessary to increase the running angle to obtain the required lift.

The slope of the moment curve also shows that it is relatively much easier to trim the machine forward than aft from the natural running position, and this assists in preventing the planes being stalled. Also, it will be noticed that if the pilot trims the machine too far forward, the resistance will increase and retard the speed, even if the moment required which, as is shown, increases more rapidly, could be applied.

Cross curves for floats are very similar to those shown for a hull, with the exception that, due to the natural tendency of floats to angle forward, as stated previously, a relatively small moment is required to overcome this, beyond which the curve becomes steep as for a hull.

An important test which has to be carried out with floats is that termed Static Longitudinal Stability. When at rest on the water, particularly in the case of small seaplanes, it is possible that personnel may stand on the stern end of the floats, or place heavy articles aft on the machine, and thereby cause a large increase in the angle at which the floats are riding to the water level. If the floats had not a required degree of longitudinal stability, particularly aft, then dangerous consequences might result.

To test for the degree of stability, the model floats are arranged to be at rest as would be the case prior to a run for resistance, etc., under conditions representing the maximum all-up weight of machine. Various moments are applied fore and aft by means of sliding weights on the framework attached to the model, and in each case the corresponding angle of trim is measured, Fig. 7. A typical curve obtained is as shown, from which it will be seen that over a reasonable range of angular movement, practically a straight line moment curve

is plotted, and that at a certain point on either side of this range, both fore and aft, the floats become unstable at the bows and stern respectively.

The slope of the straight portion of the curves is an approximate measure of the longitudinal metacentric height of the seaplane, for assuming that with an applied moment M, a small angular movement θ is obtained, whereby the inertia of the water plane does not alter appreciably, then if the weight of the machine is W, the longitudinal G.M. may be given as $M/W\tan\theta$.

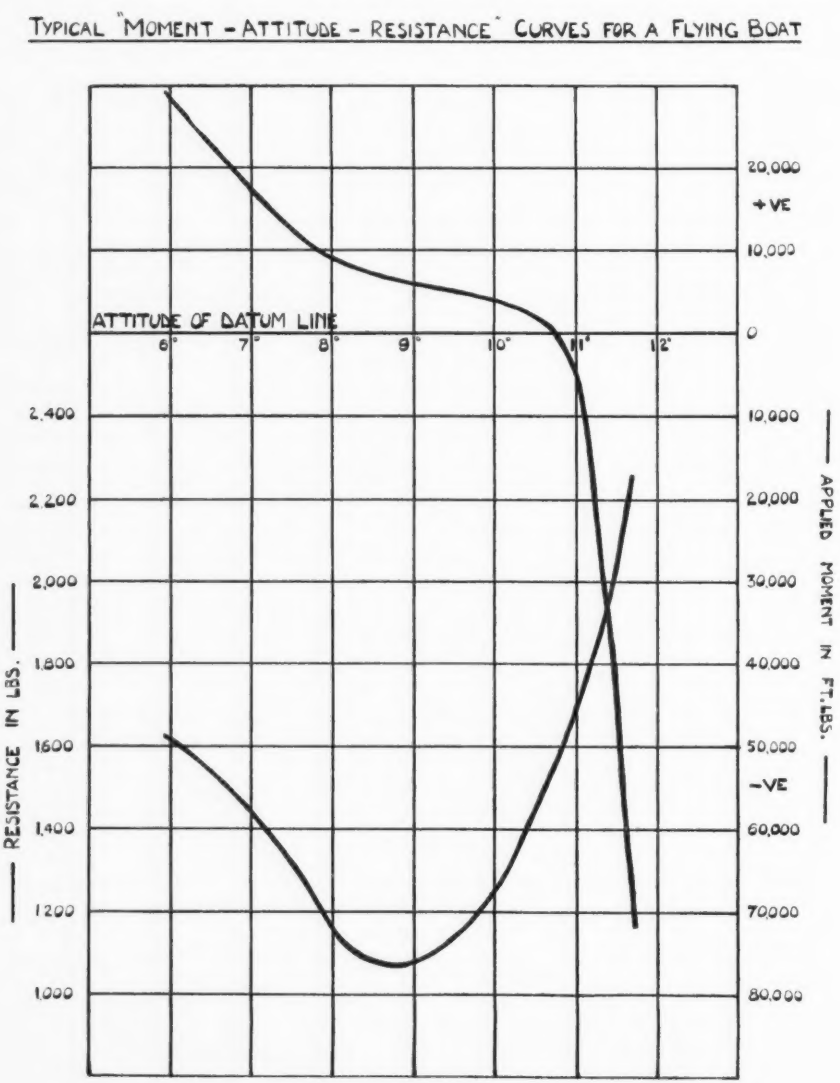


FIG. 6.

Investigation into results obtained with a number of seaplanes which had proved satisfactory, led the author to the assumption that for a reasonable degree of stability, the longitudinal G.M. measured in feet should be equal to $1.77\sqrt[3]{}$ weight of machine in lbs., and that the moment to cause instability aft be not less than (1/10) (weight of machine)$^{4/3}$.

It is essential that the waves thrown up by a hull or floats are not so excessive as to cause interference with any part of the machine during the take-off run. The waves thrown aft from a hull may cause interference with the tail unit when the machine is trimmed aft, or the bow waves may be thrown over the lower plane or into the propeller. In the case of seaplanes, the bow waves may meet between the floats, and cause a disturbance with the propeller, or the underside of the fuselage may be awash, while the fan of water thrown up from the stern

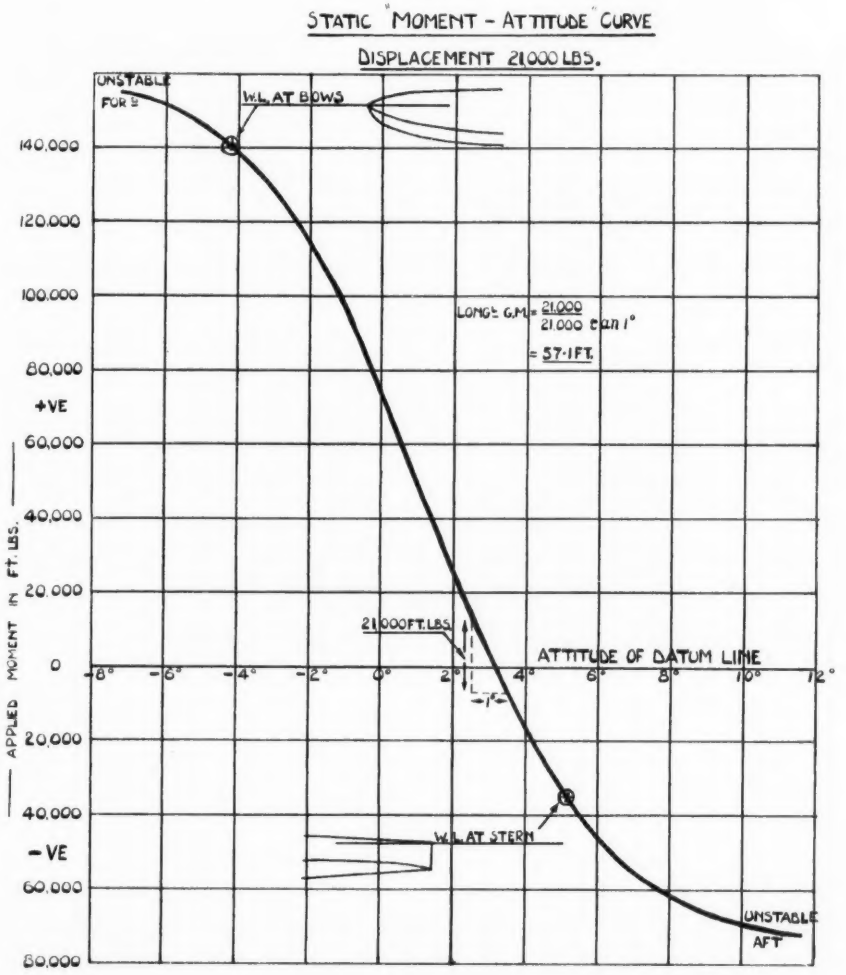
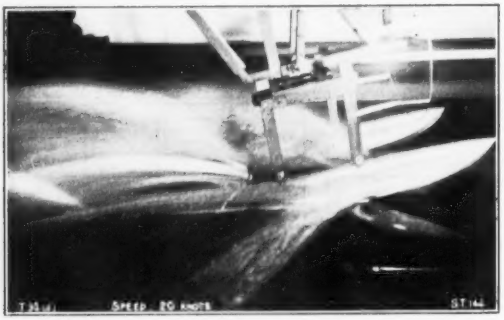


FIG. 7.

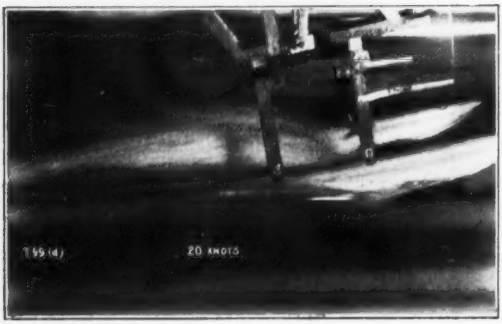
of the floats may hit the tail plane and elevators. Fig. 8 gives a clear example of how a small alteration to the shape of floats may make a tremendous difference to the degree of cleanliness. In this case only a slight modification to the chine line and transverse section near the step was necessary to make the improvement shown.

Floats on a seaplane are usually connected by horizontal cross tubes, one forward and one aft, and the position of the aft cross tube in particular is important, so as not to cause unnecessary interference with the wave formation.

Many hulls and floats at certain speeds have a tendency to develop a longitudinal oscillation which is termed "porpoising." A slow period oscillation



Before.



After.

FIG. 8.

generally need give no cause for alarm, but when a rapid period develops, the hull or floats are subject to tremendous shock loads, while the machine may even jump off the water with a possibility of stalling.

These points, as well as many others, such as the centre of gravity position, and the size of a hull or floats for a given weight of machine, etc., are investigated in a tank.

Construction

The final shape having been determined with the assistance of tank tests the preliminary "lines" drawing is replaced by the "final," incorporating the

various modifications found necessary from the tests, and this gives the entire outline shape required in the form of buttocks and waterlines, and tables of "offsets" from which the shape of the transverse frames and bulkheads may be marked out on "laying off" tables.

Next follow the various drawings showing the actual method of constructing the frames and bulkheads, indicating the gauges of material, position of flanges, lightening holes, etc., and details of rivetting the joints, and stiffening arrangements.

The frames, etc., when made, are placed in their respective positions about 20in. apart, in the cradle which has been erected. In the case of floats, watertight compartments are arranged for by erecting a bulkhead in lieu of every third or fourth frame.

Drawings are prepared in rotation so as to enable the work of building the floats to proceed, and co-operation between the drawing office and the shops

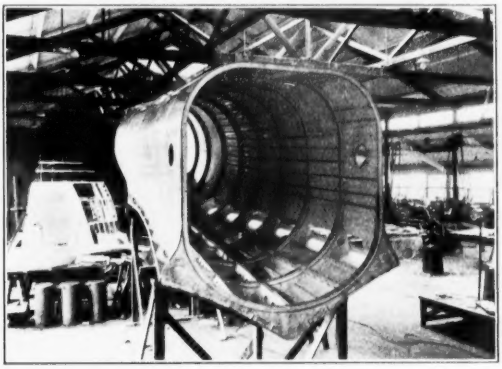


FIG. 9.

is essential in order that delay is avoided. Various castings and machined parts have to be made and ready by the time they are required to be assembled in position.

The frames and bulkheads, Fig. 9, are now connected by intercostal keelsons and stiffeners, which are checked for alignment with the aid of long ash battens, and after the internal fittings have been assembled in position, the process of fixing the sheeting can commence. For parts such as the bows and stern ends of floats, separate jigs are made, so that the sheets may be beaten into the required shape, whereas where only gradual curves are necessary, this is done by rolling, and then fitting into position on the job.

Bottom sheeting is first riveted on, followed by the side sheeting, and then after making allowance for hand holes and inspection covers, etc., or in the case of larger floats, manholes and covers, the top sheeting is secured.

In addition the various individual requirements have to be considered, such as towing bollards, walkways, bilge pumping equipment, water rudders, or even fixing for transport trolleys, etc., and arrangements made during the preparation of the constructional drawings.

The metal usually employed is duralumin, although the bottoms of a few hulls and floats have recently been plated with stainless steel sheets; all joint laps are painted before being riveted together to ensure watertightness.

As a preventive against corrosion, all duralumin sheeting, before being finally secured in position, is anodically treated by being placed for a given time in an anode-deposit salt-bath.

All watertight joints, etc., are tested under pressure, after which, if satisfactory, the floats are thoroughly dried and sprayed internally with either Rylard's white undercoating or a cellulose varnish pigmented with aluminium powder, and known as V.84. External surfaces are treated with Rylard's white undercoating and finally with white enamel or V.84.

Floats and hulls have to be constructed so as to withstand the shock loads which may be applied when alighting on the water under varying conditions of piloting and weather, and yet for a large machine of the " Calcutta " type, the bare hull is little more than one-tenth of the weight of the complete aircraft. In the case of seaplanes, the two floats weigh from 8 to 10 per cent. of the all-up weight of machine, according to size, although the best method of comparison is to consider the actual volume or displacement in terms of the weight; for instance, one type of float, having a total displacement of 1,800lbs., weighs 92lbs., when complete even to painting, *i.e.*, having a displacement of 19.75lbs. per lb. of weight. This value is for a small float as is fitted to De Havilland " Moth," Avro " Avian," or Simmonds " Spartan " machines, while in the case of larger machines 22 to 25lbs. displacement per lb. weight is obtainable.

REVIEWS

Flying as a Career

Major Oliver Stewart, M.C., A.F.C. Pitman & Sons. 3s. 6d. net

The Royal Aeronautical Society constantly receives letters the tenor of which is "How can I enter aviation?" Major Stewart's book will go a long way towards answering this question. Major Stewart begins his book with a chapter on the life of an air pilot and puts forward clearly the pros and cons. He does not hesitate to compare the risks of flying as a profession with the risks in other professions, and points out that these risks compare very favourably with those of the submarine branch of the Navy, or the professions which demand that their adherents shall live for long periods in countries where the climate is unfavourable. But, as he very rightly adds, flying offers greater scope in the future than any other profession.

Chapter II. covers the ground for obtaining an A or B licence and the next three deal with the test pilot, the pilot on the regular air lines, the pilot instructor, and joy-riding and taxi-flying. In Chapter VI the work of the air navigator is covered. As a navigator must be on board all aircraft carrying paying passengers over a hundred miles over populated country there is considerable scope here in the future for those who wish to take up flying.

Considerable amount of space is given to the prospects of the would-be airman in the Royal Air Force, and rightly so. Very full details are given for entering the service, rates of pay and the like. Major Stewart's book ends with a short chapter on aviation for women.

"Flying as a Career" is a most useful book for all who wish to enter what will, undoubtedly, be one of the great professions of the world.

Air Navigation for the Private Owner

Frank A. Swoffer, M.B.E. Pitman & Sons. 7/6 net.

Books on elementary air navigation have been wanted for some time. The teaching of air navigation is in a very elementary stage and those who have wished to learn have been forced to fall back upon what literature there is—and there is precious little of the practical kind for the private owner. In this book there is just the amount the private owner needs, written perfectly simply on the assumption that the private owner and air navigator are, in the beginning, as the poles apart. Too many authors make the mistake of assuming their readers have a certain ground work, and their books are, in consequence, above the heads of most learners. A course of elementary text-books in aeronautics, upon a definite co-ordinated plane, would prove of more value than the present haphazard publication of books which at present exists, however good some of these books may be. And "Air Navigation for the Private Owner" may very well be one of those suggested text books. It can be confidently put upon the list of recommended books on aviation.

The High-Speed Internal Combustion Engine

Harry R. Ricardo, F.R.S. Blackie and Son, Ltd. 30/- net.

This is a revised and extended edition of Vol. II of "The Internal Combustion Engine," first published by Mr. Ricardo in 1923. The present volume contains a new chapter on the high-speed Diesel engine and such additions as have been found necessary from the progress of the last seven years. As Mr.

Ricardo's original volume dealt with general principles the amount of revision necessary has actually been very little. Such revision and additions which have been made are in a sense the gilding of the lily, for Mr. Ricardo's monumental work has become a standard and will remain so.

In the chapter on the High-Speed Diesel, Mr. Ricardo gives full credit to the Royal Aircraft Establishment for the excellent work which they carried out on the development of this engine, and he points out, despite the intense development work in other countries, the results obtained by the Air Ministry eight years ago have yet to be surpassed. It is a pity Mr. Ricardo does not give more fully an account of his own pioneer work which he has been carrying out so brilliantly during the past few years for the Air Ministry.

High-Speed Diesel Engines

A. H. Goldingham. E. and F. N. Spon, Ltd. 10/6 net.

The development of the heavy oil engine is one which appears to hold out very definite hopes in various directions. That these hopes will all be fulfilled, that the compression ignition engine will be the only engine used in aircraft in the not very distant future, is unlikely. But the development of the C.I. engine to the state in which it can compete with the present day petrol engine is one which cannot but be followed with the greatest interest.

The greater part of the book describes various types of engines which have been developed and in this respect it is useful as placing on record what has and is being done. A very full discussion is given of the various fuel injection systems which are so important in this type of engine.

The Aircraft Mechanic's Handbook

Lieut. I. W. Miller. McGraw-Hill Publishing Co., Ltd. 10/- net.

Although " The Aircraft Mechanic's Handbook " is American in much of its matter, it contains so much excellent advice and so many good tips to the ground engineer and air mechanic that it will be found of very great use. The information given by Lieut. Miller is given in a highly concentrated form and the book is one which well deserves a place in the all too scant literature for the air mechanic.

CORRESPONDENCE

Jet Propulsion for Aircraft

P.O. Box 159,
Shanghai.
February 9th, 1931.

Dear Sir,—With reference to Mr. Richardson's article on the above subject in the January issue of the JOURNAL, may I add to his references Oberth's " Raumschiffahrt," which is much more reliable than Valier's writings.

Incidentally, Mr. Richardson's formulæ (1) and (2) are not correct for rocket propulsion as the change of momentum is $u-(u-v)=v$; I give the form for (2) in my letter on p. 74 of the same JOURNAL. There are some very nasty tricks in rocket theory.

Regarding the use of liquid gases, Goddard is, I believe, trying them, and Oberth tells me that he is experimenting with liquid air. His scheme is to cool the tanks, cover them with insulation till ready to fire, fill, and then strip off the insulation and fire.

Yours faithfully,
HERBERT CHATLEY.